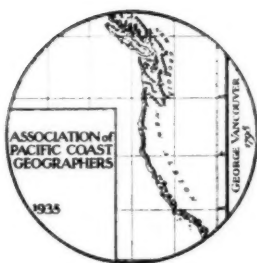


YEARBOOK *of the* ASSOCIATION *of* PACIFIC COAST GEOGRAPHERS

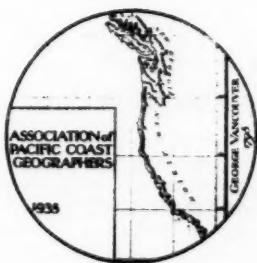


VOLUME 9, 1947

PUBLISHED BY THE ASSOCIATION AT CHENEY, WASHINGTON



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Resumption of Publication of the *Yearbook*

This is the first issue of the *Yearbook* of the Association of Pacific Coast Geographers to appear since 1943, when Volume 8 was published. Because of limitations on transportation and the absence of many of its members from their usual places of work and residence, no meetings of the Association were held in 1943, 1944, or 1945. Since the contents of the *Yearbook* depend on the programs of meetings of the Association, these years yielded no material for publication. Regular meetings were resumed in 1946. The present volume contains material from the meetings held in September, 1946, and June, 1947. It is the intention of the Association that the *Yearbook* appear in the future at the annual interval implied by its title.

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YEARBOOK OF THE ASSOCIATION OF PACIFIC COAST GEOGRAPHERS

Volume 9

1947

GEOGRAPHIC RESEARCH AND WORLD AFFAIRS*

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GEOGRAPHIC RESEARCH AND THE WAR EFFORT

DURING the war a great deal of geographic research was concentrated upon work connected directly with military operations. Geographers served as regional or functional specialists in a number of government departments. Individually and collectively they prepared various types of reports: some more geographic in character than others, depending on the nature of the problems in hand. Some reports were highly specialized and technical, designed to provide the precise and detailed information on a limited area or situation required to meet a particular military need. These included studies of beaches, harbor facilities, transportation and communication facilities, urban areas, ports, water supply, and the qualities of terrain that affect land and air operations. Some dealt with the broad aspects of very large areas and were intended to provide background information to those responsible for deciding general strategy. Others dealt with natural resources, food supplies, labor, industrial development, and other conditions likely to have a bearing upon military operations and supply. In all this research precise quantitative and qualitative information was sought, though it was not always available.

Most, if not all, of such studies required that several types of data be correlated. For example, studies of transportation involved minute analyses of routes and track profiles; of construction details of track, rails, bridges, and tunnels; of rolling stock, equipment, and maintenance facilities; of capacity; and of strategic points or bottlenecks. In other words, a transportation study synthesized geographic, engineering, and economic data to give as complete information concerning a given railroad or railroad system as was possible, and of the transport facilities it provided. Similarly, water supply problems involved geologic, climatic, and engineering data. Resource studies covered the distribution of each type of resource, and analyzed the physical and economic factors affecting its exploitation, in order that an accurate estimate of its economic potential might be arrived at.

Experience during the early months of the war showed that there were serious gaps in our information concerning other countries. Adequate geographic and economic data on both allied and enemy countries were lacking, data essential to the war effort, to military and supply operations. Information concerning the Pacific theater was particularly scanty, but the

* Presidential address before the Association of Pacific Coast Geographers, Seattle, Washington, September 20, 1946.

lack was also evident with reference to Africa, western and southern Europe, and Alaska. Such material as did exist was usually so scattered and so meager that months of intensive research were necessary if a modicum of information essential to the analysis of a problem was to be found. Even then such economic, geographic, physiographic, and geologic data as could be found were so generalized as to be almost worthless. Special missions to the field were required to fill in the gaps.

This situation gave a tremendous impetus to systematic research and to expansion of research facilities in Washington. The Division of Military Intelligence, the Office of Naval Intelligence, and the Office of Strategic Services combed the country for people who had knowledge and experience that could be brought to bear upon the war effort.

Research of the type needed requires people who have had systematic training and who have acquired a considerable body of exact information in their field of specialization. People who have experience of foreign countries, who know the language of their area of concentration, who know research techniques, and who have the ability to analyze a problem from all angles and present their findings in well organized, well written reports are essential. These skills result from both training and experience. Many people possessing these skills were drawn from the universities and colleges, but there were not enough of them, especially geographers, to meet the demand. Consequently, it was necessary to carry on an intensive in-service training of both geographers and non-geographers for geographic work.

In the early months of the war there was considerable duplication of effort among the various research agencies. Eventually, under directives issued by the Joint Chiefs of Staff, the research facilities of Washington, including those of the Office of Naval Intelligence, the Military Intelligence Division, the Army Engineers, the Air Intelligence Division, and the Office of Strategic Services were integrated. Coöperative and joint studies were inaugurated, sources of specialized and often confidential information were opened up to all contributors, and personal contacts among the working groups in the various agencies were facilitated. As a result, the research process was speeded up, the workers in different agencies were able to capitalize on each others' knowledge, skill, and experience, and duplication of effort was eliminated as far as was possible under the emergency conditions. Separately and collectively these research groups ran to earth all possible sources of information on a given area or problem, checked and rechecked them for accuracy, correlated them with information from the field, pooled their individual resources, and worked together toward a common goal.

As a result of the war effort a large number of people received intensive training in coöordinated research, and in preparing well balanced studies. Geographers broadened their backgrounds through intimate contact with other social sciences and with technical fields that are involved in regional and functional research. They acquired considerable experience, particularly in the Office of Strategic Services, in coöordinating data derived from several disciplines and specialized services. Their reports became more and more analytical rather than descriptive. As a result of these experiences, those who remain as well as those who have returned to academic life will be better able to carry on the kind of postwar research in

which the government, and particularly the Department of State, will be interested.

GEOGRAPHIC RESEARCH IN THE DEPARTMENT OF STATE

With the termination of hostilities, emphasis was shifted to economic and political issues. The principal concern of the Department of State became the formulation and implementation of policies designed to promote permanent peace, to encourage sound foreign economic rehabilitation and political stability, to promote cooperation in regard to raw materials and international trade, and to encourage peaceful and expanding international economic and cultural relations.

To provide the Department with the necessary research assistance for carrying out this work, a permanent organization has been set up under the jurisdiction of a Special Assistant to the Secretary of State, for Research and Intelligence. Since research is intended to serve the groups that form policy and take action, it must be sensitive to the needs of the offices in which departmental policy is formulated and action taken.

As research is organized in the Department at present, there are four regional research divisions, which concern themselves, respectively, with the Far East, the Near East, Middle East, and Africa, the American republics and Europe. These regional divisions require detailed information—economic, political, and geographic—of every country that falls within their jurisdiction. Their research falls into two categories. A very large amount of time and energy is devoted to the tedious business of collecting and appraising information from a multitude of sources and assembling for ready reference files of physical, economic, geographic, social, and political data on their respective areas. Major emphasis, however, is put upon the preparation of studies dealing with economic and political problems for use by those who formulate and implement the foreign policy of the United States. The research teams are composed of such regional and functional specialists—economists, geographers, and political scientists—as are needed to do particular jobs. Each report is a synthesis of the joint contributions of the team and its collaborators. The amount of geographic research that goes into any report is determined by the nature of the problem and the availability of qualified personnel. The work program of the research divisions is determined in large part by the present and anticipated needs of the regional and economic offices of the Department.

In addition to the regional divisions, there are two research divisions that handle work that is more than regional in scope. One of these, the International and Functional Intelligence Division, is concerned with a wide variety of problems that transcend regional boundaries or are international in scope. Typical of its work is a recently completed study of the world food problem, in which all of the regional divisions collaborated. Studies of natural resources, transportation and communication, population, international trade, industry, and power, world-wide in scope, are the principal interests of this division. Much of the research carried on is geographic in character, with major emphasis on economic aspects. This division operates in close cooperation with the regional divisions, upon which it depends for detailed information concerning the several parts of the earth.

The other division that is not limited to a single region is the Map Intelligence Division, which serves all government agencies.* In addition to collecting and maintaining a very comprehensive map library, and providing technical advice and expert cartographic services, it carries on a continuing program of map research. This program is made possible by its huge collection of maps from all over the earth. The reports issued consist of technical appraisals of selected maps or sets of maps of a given area, which are intended to guide those who are investigating a particular area or problem in the selection of maps. For example, "An evaluation of map coverage of frontier areas between Albania, Bulgaria, Greece, and Yugoslavia" was prepared to aid those who are studying this intricate question. Its staff is composed mainly of geographers who are especially competent in cartography, map evaluation, and map interpretation. Most of these people learned their special skills on the job in the Office of Strategic Services during the war.

Procedures have been set up for coordinating the research program of the department as a whole, for preventing duplication of effort, for facilitating the collection of information, and for maintaining high standards of research. An attempt is made to synthesize geographic, economic, and political data in well written reports, to utilize as fully as possible the research facilities and skills of both public and private institutions, to assure the study of the right things at the right time, and to get the results of these studies to the right people when they need them.

PRIVATE GEOGRAPHIC RESEARCH USEFUL TO THE DEPARTMENT OF STATE

Much geographic research that would be of ultimate value to the Department of State can be done "on campus" by any well trained geographer who has adequate background in economics or political science and an interest in international relations. Campus research of the type needed is practicable. A vast amount of basic information can be obtained from newspapers, scientific and technical journals, and books. If these sources can be supplemented by well planned field studies, a very substantial contribution can be made to our knowledge. Training both in particular areas and in non-regional specialties, and experience in field techniques, should enable geographers to carry on work that would be extremely useful to the Department.

There are, of course, certain limitations to what can be done outside the department. Problems that require the use of confidential or secret sources of information should be avoided, since this kind of material is not available for private use. Some types of research require special equipment beyond the resources of a university. Map research, for example, is practicable only where large and complete map collections are available. Campus research of interest to the International and Functional Intelligence Division and the four regional divisions is much more feasible, and offers a wealth of opportunity. Many economic geographers are qualified to carry on effective research on such topics as natural resources, trans-

* Since this paper was written the Map Intelligence Division has been transferred from the State Department to the National Intelligence Authority. Its functions and responsibilities, however, remain the same.

port and communications, population, industry, international trade, and power, on a world-wide basis. There are numerous outlets for the publication of studies of this kind in professional and scientific journals. Such studies, made available through publication, would be extremely useful to the Department of State.

The regional divisions need specific information on every aspect of the countries with which they are concerned. Geographers with a flair for synthesizing physical, economic, social, and political data in detailed area studies have a rich field for productive research. Scientific studies of the land, the people, resources, and economic development, especially if supported by adequate field work, will contribute significantly to the work of the Department. Area studies of this type are needed by all the research divisions, and particularly by the division concerned with the Far East.

Little of the basic work on problems or segments of problems of the type that the Department may ultimately find useful needs to be done in Washington. Whenever the necessary data can be gathered from published sources, it can be done effectively in the universities, and should be done there. Owing to pressure of other work, the Department cannot undertake all the basic research that is necessary. Consequently it hopes to foster and maintain liaison with private institutions throughout the country for the purpose of utilizing all possible resources for research. The research divisions are interested in stimulating university research, through direct personal contacts and consultations, along lines suited to their needs.

SNOW AS AN ENVIRONMENTAL FACTOR IN THE WEST*

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IT IS NOT necessary for me to remind geographers of the various factors of the physical environment. All recall that climate is one of them, and that climate is judged by many in the profession to be the most important of the physical factors. Climate can be conducive, passive, or restrictive to many of man's activities. In some areas the governing element of climate may be temperature, in others it may be precipitation, in still others it may be wind or some other climatic element or combination of elements.

There are many combinations of temperature and precipitation in the West. This variety results from its wide latitudinal range, its great longitudinal breadth, its high and continuous mountain ranges, its low river valleys, its extensive plateaus, its position downwind from the adjacent ocean, and the characteristics and frequency of the air masses that traverse the region or meet within it.

Although the absolute highest and lowest temperatures recorded in this country have been observed within the western states, temperatures, by and large, are satisfactory for raising most of the major food crops. Other climatic elements, except one, are in the main conducive or passive. The restrictive element is water, despite the fact the the largest amount of precipitation in the United States falls in the state of Washington. Except for a few favored areas, most of the West lacks sufficient water at the right time of the year for agriculture unaided by irrigation. In this respect the West is in marked contrast to all the country east of the meridian of 100° west longitude. Agriculturally the West is thirsty. For other activities of man the West is dry, too.

Such development as the West has experienced has been largely dependent on water; and future development will be more and more dependent on water. It has been envisaged by some that the West will finally cease to grow in population, not because of land and opportunities, but because there will not be enough water to support any more people. Mr. John Haw, in an address before the Annual Meeting of the Western Snow Conference in Portland, Oregon, April 22, 1947, said that "every drop that falls, regardless of form, must be held, hoarded, and harnessed to many jobs before it is allowed to escape to the sea."

Over the larger part of the West, most of the precipitation comes in the colder half-year; and much of that winter precipitation falls in the form of snow in the high mountains, where temperatures are below freezing. The fact that it falls in the wrong season for agriculture is compensated by its falling in the solid form. It cannot be utilized until it is liquefied. Liquefaction occurs at the right season, agriculturally.

Over flat terrain it is easy to obtain a sampling of the amount of precipitation that falls in a year, multiply it by the area and so obtain a first approximation of the total volume of water that falls and will become

* Presidential Address before the Association of Pacific Coast Geographers, San Diego, California, June 20, 1947.

available. In mountains the problem is not so simple. However, where snow falls in the mountains and forms a large fraction of the precipitation for the year, it is possible to forecast quite accurately the amount of water that will flow in the streams during the summer season. Knowledge of the summer water supply in streams is the direct result of snow measurements. These are made approximately on April first, at numerous snow courses in all the Western states. An inventory is thus taken of the water stored in the snow-pack at the end of winter. Most of this water will enter the streams. Because spring and summer precipitation is small, though locally it may form a large percentage of the total annual precipitation, the total stream flow in summer is usually modified only slightly by warm season precipitation.

This paper is not the place for a discussion of the methods of determining the water content of the snow-pack or of reducing to total discharge of the streams the amount of snow measured at the end of winter. A little history, however, may not be amiss. Nearly forty years ago Dr. J. E. Church, of the University of Nevada, perhaps a distant relative of mine, saw the problem and initiated the science of snow measurement. In its early stages, his work was directed toward showing the direct relation between water content of the snow-pack and available water in streams in the following growing season. His pioneer work has had remarkable repercussions. Nearly all countries on which snow falls and which have irrigated or potentially irrigable land have adopted the methods he devised. Australia, India, Chile, and China are the latest countries to request his advice and aid in setting up snow surveys and interpreting the data from them.

Shortly after it was shown that there was a relation between water content of snow-pack and available water in streams the following summer, those who became interested in snow surveying and its ramifications organized the Western Interstate Snow Survey Conference, since shortened to Western Snow Conference. Its annual meetings are held in April.

Years later an Eastern Snow Conference was formed. In December, 1941, a Central Snow Conference came into existence. In each of these organizations, the problems that arise from snow in their respective areas are considered. Each area has problems that are quite different, cryologically speaking.

The general tenor of the Eastern Snow Conference shows that it is primarily interested in the problems of removal of snow from streets, highways, and airports: the amount of heat required to melt snow, together with methods and processes that encourage rapid natural removal of snow; and the effectiveness of snow-melt in producing damaging floods. A little is done in studying the characteristics of snow in relation to skiing and snowshoeing. At the first meeting of the Central Snow Conference in 1941, attendance at which represented a cross-section of interests from Ohio to Alberta, several themes were conspicuous. Members from Ohio, Indiana, Illinois, and Michigan were primarily concerned with the destructive effort of snow on various crops, especially tree crops, and on the fish population in streams. Those from Michigan, Wisconsin, and Minnesota emphasized snow for skiing and snowshoeing and removal of snow from highways. Members from South Dakota, North Dakota, and the prairie

provinces of Canada were interested in deriving as much water as possible from the snow where it falls.

The papers read at the numerous meetings of the Western Snow Conference reflect an attitude far removed from the attitudes of its younger sister organizations. The East wants to get rid of snow, and regards it chiefly as a nuisance; the Mid-West is not especially happy over the occurrence of the snow that falls; and the spring wheat area, which has only a marginal amount of precipitation, looks upon snow as a possible supplementary source of moisture. The West, on the other hand, dependent on snow, views it with utmost respect. Each inch of snow means food, power, industry, and life; not money spent. The late Major E. H. Bowie expressed the antithesis tersely: "Snow in the Mid-West and East is something to shovel; in the West it is life-blood."

The relation of water content of snow-pack to stream flow must be worked out for each stream. This work requires a good deal of exploration, trial and error, and refinement of methods. Most streams of the West have been subjected to such study; as a result, forecasting of stream flow from snow measurements has reached a high degree of accuracy. The forecaster looks upon an error of more than ten per cent in the forecast of stream discharge as poor. Most forecasts are now within five per cent of the runoff in streams whose characteristics are well known. Forecasting of runoff from snow-pack has become an exact science.

Marked departure of snowfall from the mean have occurred. Meteorologically, when the zonal index of the westerly winds is low, little snow accumulates in the mountains; a high zonal index is associated with a large amount. The windier the winter, with westerly winds, the greater the snowfall; the less the wind velocity, the less is the snowfall.

Let me cite the conditions that obtained during the past two winters, and some of their results. In the winter of 1945-46, a high zonal index prevailed north of San Francisco, and a low index to the south of it. The snow-pack was above the average (for the decade 1935-45) north and west of a line that ran approximately from San Francisco to Great Falls, Montana. Washington had about 150 per cent, Oregon from 95 to 300 per cent above normal. On the other hand, southeast of the line separating the area of high from that of low index, there was a deficiency of snow, which increased with distance southeastward until in New Mexico the snow-pack was less than 50 per cent of normal. Needless to say, the distribution of discharge of water in streams in the following summer was parallel to the distribution of water content of the snow-pack.

In the following summer, that of 1946, the Yakima River had more water than ever before in its history; some acreage, in fact, was flooded. There were floods in western Washington. Much water had to be "dumped" from Lake Chelan and Pend Oreille Lake. The Columbia River flooded farm land along its lower course. Oregon had a large surplus of water, and many acres were planted that normally would not have been. In Crook County, Oregon, alone, 4,000 additional acres were seeded because a forecast of inflow into the Ochoco reservoir was for 285% above normal flow. The additional income of the farmers who heeded the forecast and planted additional acreage was approximately \$500,000. Storage res-

ervoirs were filled to capacity; and since the discharge of the streams was above normal longer than usual, more water than usual was held in storage at the end of the irrigation year. Floods in the Kootenai Valley were predicted; they materialized, but since dikes had been strengthened and heightened when high water was forecast, the floods did little damage. Warned of impending floods, owners of undiked lands refrained from planting some 2,000 acres of river-bottom land, this land was subsequently inundated. Seed and labor would have been lost if the land had been planted in spite of the forecast of flood.

In the Southwest there was a severe shortage of water. The San Carlos project in Arizona, for example, which in years of good water supply has about 100,000 acres seeded, had little water. The forecast made on March 15 stated that because of the small inflow expected the water supply would be extremely limited. In view of the forecast issued prior to seeding, some 60,000 acres of the potential crop land was not seeded. In spite of this restriction in the area planted, there was no usable water in storage from June 24 to July 18. This was the first time in seventeen years that there had been none. Further instances might be cited.

The winter just past has been somewhat different from the previous one. The state of Washington had less snow than in 1945-46; the snow-pack was just about normal. Oregon, in general, had about 60 to 80 per cent of normal. Severe shortages of water will be experienced in Arizona, Nevada, and most of California. To the northeast of a line drawn from Puget Sound to Pueblo, Colorado, there was a surplus of snow. Though many streams in the Southwest will have subnormal flow from melting snow, the hold-over water in storage is also below normal. R. A. Work and Paul A. Ewing, of the Soil Conservation Service, report that as of April 1, 1947, reservoir storage in Arizona was only fifteen per cent of total capacity, as compared with an average of 40 per cent of capacity in the decade 1936-45. The hold-over behind Boulder Dam dropped to 59 per cent as compared with an average of 72 per cent in the period 1936-45. California will have a meager supply of water from last winter's snow, but the hold-over storage from last year is considerably higher than in Arizona. Conditions in New Mexico are somewhat improved over 1945-46. Eastern Oregon will have to depend partly on hold-over water from last year. Water in the main stem of the Columbia River will be ample for all purposes.

Two successive years of poor water supply are not conducive to expansion in Arizona. Californians, too, are not happy at their prospects, nor should they be. At the Western Snow Conference in Portland in April, 1947, several Californians mentioned that the water of the Columbia River is being eyed as a possible means of alleviating the growing and insatiable thirst of their state.

But water is used for many purposes other than irrigation. It is used for power, for navigation, for industrial, commercial, and domestic supplies, for recreation, for fisheries. The many uses of water bring about a conflict of interests, and the conflict will grow more serious as more people settle in the West. How much water falls in the West? Is there enough for all? How much can be used for this and how much for that purpose? These are large problems, the solutions of which will require much thought and work.

The interests of power and irrigation generally conflict because the periods of their maximum use of water are completely out of phase. The demand for electricity is at a maximum in winter, the period of minimum discharge of snow-fed streams. In the Northwest, the total generating capacity now exceeds 4,000,000 kilowatts. This is produced by 294 generating plants. Of the total power generated, 88 per cent is from hydroelectric plants. The power resources of the major utilities are pooled months in advance for the most economical generation. Operators of hydroelectric plants are concerned with water supplies, and with the amount that will be available each season. In years of good water supply, less auxiliary fuel is needed. Though nearly nine-tenths of the power is generated by water, about 2,000,000 tons of coal and 2,000,000 barrels of oil are normally required to produce the remainder. Forecasts from snow surveys greatly influence the timing of the orders, the amount, the delivery dates, and places of storage of this auxiliary fuel.

The operators of hydroelectric plants, who are interested in the firm flow of streams, especially in the fall and early winter when demand for power is increasing, must plan operations months in advance. They depend to a great extent on summer discharge to fill their storage reservoirs. But many reservoirs are limited by law to fixed upper and lower levels. Lake Chelan, in Washington, is a good example of reservoirs thus regulated. The Washington Water Power Company operates a 57,000-kilowatt plant on Chelan River below the outlet of the lake. The storage capacity of the lake is 678,000 acre feet between the minimum and maximum levels between which the lake may be manipulated. In years of large inflow from much snow, it is important to discharge water at a uniform rate of such magnitude that no damage results below the power plant, but also to fill the lake to the upper permissible limit. In years of little inflow, most of the runoff to the lake is required to fill it to its upper limit. In this circumstance, the Chelan plant is shut down, and the power load is transferred to some other plant, in order that the reservoir may be filled. Each foot of water above the lower limit of the reservoir is valued by the Company at \$25,000; hence it is greatly concerned with forecasts made from snow surveys. This year Lake Chelan will have such a surplus that five feet of water will have to be spilled.

Lake Tahoe is another example of the same category. This lake, too, has an upper permissible limit; if it is exceeded, there are damage suits against the users of water. The spillway of the lake has a small capacity. Hence, if too little water is withdrawn from the lake before the peak inflow occurs, the lake may rise above its upper limit. Conversely, if too much water is withdrawn, the lake may not be filled. Power and irrigation interests along the Truckee River value each foot of water below the upper limit at \$250,000. The exact amount of water that can be released before the inflow from melting snow commences is computed largely from the results of snow surveys. The lake must fill, but not over-fill.

One further example must be cited; it involves irrigation, power, industrial concerns, and private landholders. Again, it is water from melting snow that forms the central theme. I quote the basic facts directly from a letter received this month from R. A. Work, Senior Irrigation Engineer, Soil Conservation Service, Medford, Oregon:

"Part of the water stored in Upper Klamath Lake, Oregon, is used for irrigation and part of the balance is released during low flow season to hydroelectric generation units of the California Oregon Power Company. Lake water flows through Link River into Lake Ewauna, which forms a huge after-bay. On the shores of the after-bay are located numerous saw-mills and other industrial plants and bordering the shore is some acreage of tillable land. Likewise, nearly surrounding the perimeter of Upper Klamath Lake are agricultural lands, fishing and hunting lodges, saw-mills, and other enterprises. Allowing either Upper Klamath Lake or Ewauna Lake to reach a high level injures agricultural lands and hampers industrial operations. Allowing Upper Klamath Lake to drop to low level, of course, reduces not only the available irrigation supplies, but acre feet for kilowatt generation as well. Maximum and minimum gage heights have, therefore, been established. Should the maximum gage height be exceeded, the power company would be subject to suits for damages or other penalties. The quick release of large heads of water from Upper Klamath Lake through Link River to prevent Upper Klamath Lake from exceeding the maximum gage height results in production of an excessive height in the after-bay and the power company has contracted with various industries not to do this. Furthermore, the carrying capacity of Link River is limited. Therefore, it is essential that inflow to Upper Klamath Lake be accurately predicted in advance of actual spring inflow in order that sufficient water may slowly be released, if necessary, before the main inflow period to prevent Upper Klamath Lake from exceeding the maximum gage height. If inflow does not equal predicted inflow, then available storage is lost because of the early wastage down Link River and every acre foot so lost means revenue loss to the power company because of decreased kilowatt production."

May I speculate a bit with regard to the future? Water is wasted in all states. It certainly is possible to make more efficient use of the water resources of the West. Let me refresh your memory that Secretary of the Interior Krug says that to make efficient use of the Colorado River, to "harness" it, if you please, will cost more than \$2,000,000,000 in addition to what has already been spent on it. To do the same for the Columbia will cost \$5,500,000,000. That is a large sum of money to spend; and it won't make any more water for the west.

There is a growing possibility of piping water to the areas of deficiency. That possibility was mentioned earlier in this paper, perhaps with some levity. But it is a serious matter. A few days ago a front-page item in a Seattle newspaper reported that California was looking to the Northwest as a place from which water could be obtained. The newspaper further quoted a senator who says that it would be more feasible to "desalt" ocean water. Both of these ideas need some sort of testing; they should not be cast off without serious consideration. How far can water be piped economically? If "desalting" of sea-water could be done economically, how high could it be pumped and how far could it be piped without the cost and delivery charges becoming prohibitive?

One further item needs discussion. During most of the growing season the air over the West has a large moisture saturation deficit. The condensation level is high above the surface, higher than most of the western mountains. The freezing level is still higher than the condensa-

tion level. Pluviculture has not yet reached the stage at which precipitation can be produced from air with a saturation deficit. It is not likely, though perhaps not impossible, that that stage will ever be reached. It would be a boon to the West if rain could be precipitated at will. But in the past year certain experiments performed in the East by Dr. Irving Langmuir and Mr. Vincent Schaefer of the General Electric Research Laboratory, and repeated once in Oregon this spring and several times in Australia, have shown without a doubt that under certain meteorological conditions man can induce snow to form in the atmosphere. The experiments prove that it is easy and cheap to produce a great deal of snow; and it appears that the place of deposition of snow thus produced may be controlled. Happily, the meteorological conditions necessary for the artificial precipitation of snow are present in the West during much of the winter. Of course there are some disadvantages to producing artificial snowstorms, but these will likely shrink to insignificance in comparison with the benefits that may accrue. This process may in time play an important role in the further development of the Western States.

In conclusion I wish to emphasize again that there is insufficient precipitation over most of the West, except at high altitudes. Because the precipitation at high latitudes is mainly snow, an accurate estimate of the amount of water that will be available in summer following the winter snowfall can be made. The demands for water are continually increasing; the basic amount remains relatively constant from year to year. Though at present much water is allowed to reach the ocean without being utilized, each year the unused volume becomes smaller. To make the most intelligent and efficient use of the water available, it is necessary to know more about the amount and characteristics of the snow from which so much of the western water is derived. It may become feasible to induce artificially a greater fall of snow in the headwaters of many streams. This procedure may be cheaper and more successful than trying to distribute water from areas of excess to places of deficiency. Water first reaches the land surface in some form of precipitation: rain, sleet, hail, or snow. No matter how much is used or how it is used, there is a deficiency in the West. Because man's activities in the West are thus restricted by lack of water, it is certain that the magnitude of his endeavors will be largely governed by snow.

DEVELOPMENT OF THE COLUMBIA BASIN RECLAMATION PROJECT

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THE Columbia Basin Project, situated in central Washington, has two primary purposes: the production of hydroelectric power and the reclamation of arid lands. By regulating the flow of the Columbia River, the hydroelectric works associated with the project have also improved navigation on the river, and have helped to prevent floods. All these purposes will apparently be gained without damaging the important salmon fisheries on the Columbia.

PHYSICAL SETTING

The project lies in the Columbia Intermontane Province, between the Rocky Mountains and the Cascades. The area is underlain by basalt flows, which are locally interbedded with lake deposits and other terrestrial sediments. In places, the thickness of the lava and sediments exceeds 5,000 feet. Superficial deposits left by running water, winds, and glaciers often mask the bed rock, and the soil is generally derived from these transported materials rather than from the underlying hard rock.

Except for some high hills, most numerous near the margin of the area, the lavas of the Columbia Basin formed a plain. Following the period of vulcanism, the lavas were warped and folded. The downwarps determined the position of the Pasco and Quincy basins, the principal areas to be irrigated. The upfolds form many ridges to the south and west of the central plains; two of these ridges, Saddle Mountains and Frenchman Hills, extend east of the Columbia River and nearly separate the Quincy from the Pasco Basin (Fig. 1).

The Columbia River crosses central Washington in a roundabout course, in such a manner as to enclose the Big Bend country on three sides. The southern part of the Big Bend country includes the territory to be irrigated in the Columbia Basin project. On the north of the Big Bend, the eruptions of lava forced the Columbia River to flow along the southern edge of the Okanogan Highlands, where it has incised itself in deep gorges floored with granite. These gorges provide excellent dam sites.

During the Glacial epoch, lobes of ice moved south from Canada into the Big Bend country and the region about Spokane. The ice blocked the Columbia to form a lake about 1,500 feet deep, the overflow from which eroded the Grand Coluee. I have named this body of water Lake Nespelem. Farther east a part of the glacier, and in the absence of ice the glacial meltwater, overflowed the divide that here lies only a few miles from the Columbia and Spokane valleys. Huge torrents or giant sheet floods cascaded southward, descending nearly 2,000 feet in a little more than 100 miles before tumbling into the Snake and lower Columbia Rivers. Erosion by the floods of meltwater removed the surface soil from wide strips of country, and exposed the bare lava. The pioneers called this denuded lava "scabrock." J Harlan Bretz has called this curious country "The Channeled Scablands," and has described it in numerous papers. Débris eroded from the scablands was in part spread out over the Quincy and Pasco

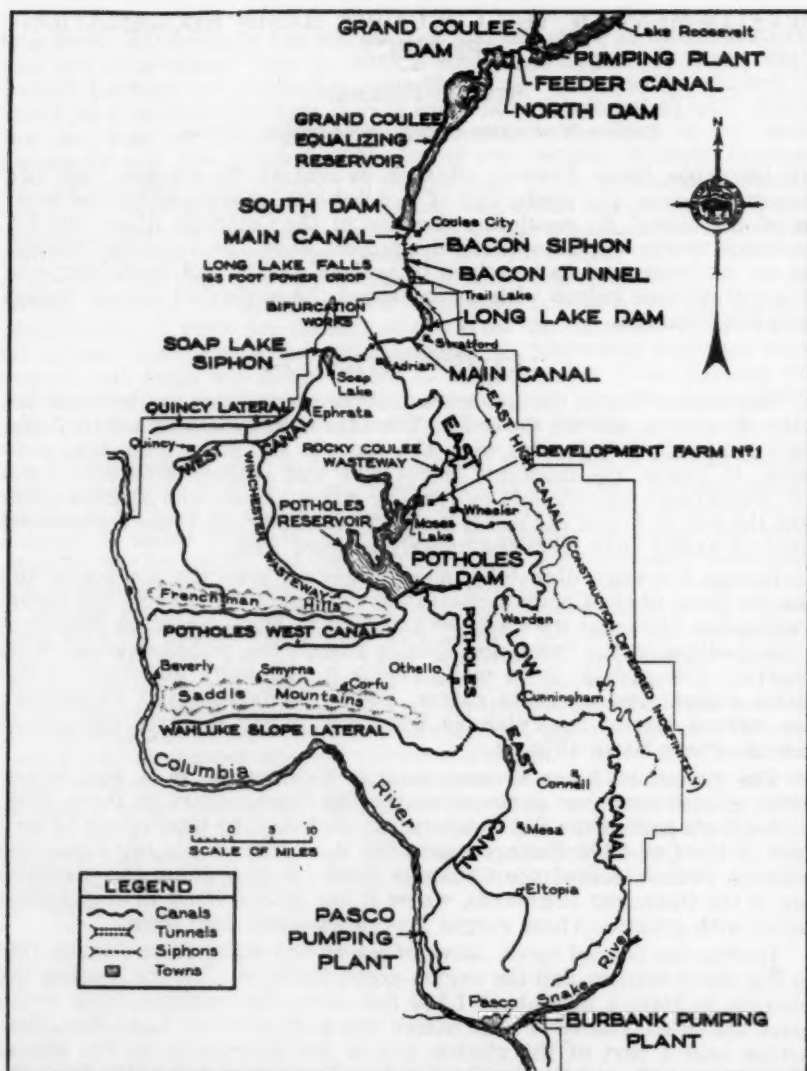


FIG. 1. General map of the Columbia Basin Project. (United States Bureau of Reclamation.)

basins. These deposits are level or gently sloping, and constitute superior soils for irrigation. Some deposits of coarse gravel and windblown sand within the basins are unsuited for cultivation, as are also exposures of bare rock and certain elevated ridges. Of some 2,000,000 acres included in the Columbia River Project, about 1,000,000 acres are considered tillable.

The scabland channels, which are often followed by railroads and highways, will be utilized in part for reservoirs and irrigation canals.

The Columbia Basin lies in the lee of the Cascade Mountains, and receives no more than six to ten inches of rainfall annually; too little, except in very favorable years, for profitable wheat growing by dry-farming methods. Irrigation is therefore a requisite for the dependable production of crops. Other features of the climate, however, such as a high percentage of possible sunshine in summer, and a growing season that ranges from 150 to more than 200 frost-free days, are favorable for agriculture.

The Columbia River, the annual discharge of which exceeds that of any other western river, provides an inexhaustible supply of water for irrigation. Most of the best soil within the area of the project is, however, situated so high above the river that individual pumping installations are too expensive. A Grand Coulee Dam and the biggest pumps ever built are required to make irrigation practicable. The average annual discharge of the Columbia is 79,000,000 acre feet, five times that of the Colorado River at Hoover Dam.

GRAND COULEE DAM

Grand Coulee Dam was begun as a project of the Public Works Administration, which in July, 1933, allotted \$63,000,000 for the construction of a "low" dam 177 feet high, suitable only for hydroelectric power. Excavation was begun, but in 1935, before any concrete had been poured, plans were changed, and the height of the proposed dam increased in order to serve the purpose of both power and irrigation. Supervision of the construction was transferred to the United States Bureau of Reclamation, and the work of building the dam and powerhouses continued day and night. The first turbine-generator, of 144,000 horse power, was installed in 1941; by 1947 six such generators were in operation, and three more were soon to be completed. All these are in the power house at the west end of the dam. Nine more generators will be installed in a second power house at the east end. Congress has already appropriated funds for three of them. The planned capacity of Grand Coulee Dam is 2,600,000 horse power (1,944,000 kilowatts), of which one-half will be available early in 1948. During the war, power from Grand Coulee was used for the smelting of aluminum and magnesium, in aircraft factories and shipyards, and in the manufacture of plutonium for the atomic bomb.

The dam is built at the head of Grand Coulee, on a foundation of firm granite. It is 4,300 feet long, 500 feet wide at the base, 30 feet wide at the top, rises 550 feet above the lowest bed rock, and contains 11,250,000 cubic yards of concrete. It has an effective head of about 300 feet. Behind it, Lake Roosevelt extends upstream 151 miles to the Canadian boundary; the elevation of the river at the boundary was the factor that determined the height of the dam. The site of the dam was chosen in preference to other possible sites because of the ease with which water from Lake Roosevelt can be pumped up 280 feet to an equalizing reservoir in upper Grand Coulee, from which it will flow to irrigate the Columbia Basin. Other advantages of the site were proximity to great deposits of sand and gravel for concrete, and to space in Rattlesnake Canyon for dumping more than 20,000,000 cubic yards of overburden that had to be removed from above the granite before any concrete could be poured. The Columbia River has

its season of high water in summer, when the requirements for irrigation water are at a maximum. Its discharge is so great that all needs for water can be supplied without any seasonal diminution of the output of power. The level of Lake Roosevelt will remain uniform throughout the year. The lake and its shores can therefore be conveniently used for recreation. The federal government has retained ownership of a strip of land along the entire shore line of Lake Roosevelt, so that the recreational use of the lake can be completely controlled, and unsuitable resorts excluded. Grand Coulee Dam itself, incidentally, is a major tourist attraction; 340,000 persons visited the dam and power house in 1947.

The large quantity of cheap hydroelectric power available from Grand Coulee, which will be available in the near future, is a great attraction to industry. The sale of power makes the Grand Coulee Dam and its power plant and distribution system a self-liquidating enterprise. Increased industrialization will help provide markets within the Pacific Northwest for much of the farm produce that will come from the lands to be irrigated.



FIG. 2. Upper Grand Coulee, site of the Equalizing Reservoir.

THE IRRIGATION PROJECT

The irrigation works now under construction will consist of the following parts: 1, a main pumping plant at Grand Coulee Dam; 2, the Equalizing Reservoir, 27 miles long, in the upper Grand Coulee, held by two dams built of earth and rock, North Dam and South Dam; and 3, a distributing system that will receive water from the Equalizing Reservoir. The distributing system will include two dams of earth and rock, Potholes and Long Lake Dams, and a main canal, which will bifurcate into a West Canal 80 miles long and an East Canal 130 miles long. The latter will also serve the southern section of the project. Potholes Reservoir is a part of this system, but it will also capture some runoff and drainage water, and will furnish water to land lying west and south of it. The irrigation system is the largest single installation of its kind ever planned in the United States.

The pumping plant will use power generated at Grand Coulee Dam. The pumps will be installed in a wing dam upstream from the power house at the west end of the Dam. There will be 12 pumping units, in each of

which a pump having a capacity of 1,600 cubic feet (12,000 gallons) per second will be driven by a 65,777-horsepower motor. Any one of these units could supply all the water required by the city of New York. The water will be lifted 280 feet, through conduits cut in solid granite, into the Feeder Canal, which will be 1.6 miles long, 25 feet deep, 125 feet wide at the top and 50 feet wide at the bottom. The Feeder Canal will carry water to the Equalizing Reservoir, which will be held by earth-fill dams at the northern and southern ends of upper Grand Coulee (Fig. 2).

The Equalizing Reservoir will be 27 miles long and 1.5 miles wide, and will cover most of the floor of the upper Grand Coulee. Its active storage capacity will be 700,000 acre feet. The railroad and highway that now traverse the floor of the Coulee will have to be moved to higher ground. Steamboat Rock, a landmark in the widest part of the Coulee, is expected to become an island. North Dam, 1.5 miles from Grand Coulee Dam, will have a maximum height of 115 feet above the lowest foundation rock, and a length of about 1,400 feet. South Dam is under construction near Coulee City. It will be 10,000 feet long, 65 feet high, 450 feet thick at the base and 42 feet wide at the top, and will carry a highway. Both dams will be built of earth and rock over a core of concrete five feet thick, which fills a trench cut into the bed rock and rises several feet above the original surface. Clay, sand, and gravel are added, and compacted with heavy rollers while wet, to prevent seepage. An outside facing of rock will protect the dam from erosion by waves.

From the eastern side of South Dam the Main Canal will carry water southward to the Bifurcation Works near Adrian, where it will be divided between the East Low Canal and the West Canal. The Main Canal is about 20 miles long; because of the large amount of excavation of rock required, it will be expensive. At the north, the canal traverses hard basalt for 1.3 miles; a part of this stretch will be lined with concrete. The maximum cut is 90 feet, the top width 120 feet, and the bottom width 50 feet. The canal will convey a stream of water 36 feet deep, to irrigate 1,000,000 acres of land. Next comes the Bacon Siphon, of reinforced concrete, 1,000 feet long and 23 feet in inside diameter, which will carry the water across a dry canyon into Bacon Tunnel. This tunnel will be cut for two miles through hard lava, will be lined with concrete, and have a finished diameter of 23 feet. The contract cost of the siphon and tunnel is \$3,394,000. For four miles after passing the tunnel, the Main Canal follows a natural channel, which is dry most of the year but is called Trail Lake. This part of the Main Canal ends on the rimrock above Long Lake Coulee, where the water will plunge 165 feet into Long Lake. It will thus recreate a waterfall that vanished at the close of the Glacial Period. Ultimately, the East High Canal will take off above the falls and irrigate 200,000 acres now used for dry-land wheat farming. Construction of this canal has been indefinitely deferred, in part because high prices for wheat and rainfall above the average since 1940 have led to the withdrawal of a large part of the privately owned land intended to be irrigated from it. If it is ever needed, a good deal of power can be generated at the artificial falls.

Long Lake Dam, near Stratford, is not a storage dam, but a part of the Main Canal. Its purpose is to save 5.5 miles of difficult and costly construction, mostly in hard rock, by blocking a canyon at its mouth. The dam will be an earth-and-rock fill 1,900 feet long, 600 feet wide at the bottom, 20 feet wide at the top, and 130 feet above the lowest bed rock.

It will cost \$1,770,000. The present three small lakes in Long Lake Coulee will become a substantial body of water 5.5 miles long with an average width of one-third of a mile and a maximum depth of 100 feet. From Long Lake Dam the Main Canal (Fig. 3) runs southwestward 6.6 miles to the Bifurcation Works. Here the canal is 120 feet wide at the water surface and 50 feet wide at the bottom. It is planned to carry a flow of water 21 feet deep, sufficient to irrigate 800,000 acres.

At the Bifurcation Works the West Canal and East Low Canal diverge. The West Canal, 88 miles long, will supply 281,000 acres, mostly in the Quincy Basin. It winds along near the northern and western boundaries



FIG. 3. Excavating the Main Canal, near Stratford. (United States Bureau of Reclamation.)

of the project to Frenchman Hills, and will pass through them in a tunnel 9,150 feet long, to irrigate the Royal Slope on their southern side. The contract cost of the first 6.5 miles of the West Canal, including two siphons having a combined length of more than a mile, is \$2,871,796. The siphons, known as Dry Coulee Siphons 1 and 2, will be 25 feet in diameter, and the largest in the Pacific Northwest. The waters of the West Canal will be carried across the lower Grand Coulee north of Soap Lake by Soap Lake Siphon, 12,000 feet in length, which is not yet under construction.

The East Low Canal will be 130 miles long, reaching nearly to Pasco, and will irrigate 252,000 acres. The first section, 12.3 miles long, is under construction at a contract cost of \$3,977,000. The parts lined with concrete will have an average width of 76 feet at the water surface, and 20 feet at the bottom. The unlined parts will have larger dimensions. Concrete construction, where required, is facilitated by an abundance of sand and gravel deposited by flood waters during the Glacial Period.

Potholes Dam, near the center of the project, will be the largest of the four earth-fill dams in the system, and the fourth longest dam in the United States. It will contain 9,200,000 cubic yards of material, and its contract cost is \$9,359,000. Its length, along an irregular east-west trace, is 3.5 miles, and its maximum height more than 200 feet above bed rock. Potholes Reservoir will cover 47 square miles. It will back water into Moses Lake and raise the level of that body of water by five or six feet. Its shoreline will be 250 miles long. This reservoir will have a capacity of 615,000 acre-feet of water, of which 250,000 can be used for irrigation. It will be supplied from both the West Canal and the East Low Canal, but will also receive drainage water from the northern part of the project for redistribution.

Two canals lead from Potholes Reservoir. Potholes East Canal will reach almost to Pasco, and will serve 254,000 acres. This area includes the Wahluke Slope on the southern side of Saddle Mountains, to which water will be led through a branch canal. Potholes West Canal will supply water



FIG. 4. Scene on demonstration farm near Moses Lake.

to 13,600 acres along the base of the Royal Slope south of Frenchman Hills. The Potholes area contains many sand dunes; some of these will be inundated, but others will make excellent beaches for recreation.

Approximately 12 miles north of Pasco, a pumping plant and a system of lateral canals are almost completed. Here 5,360 acres, divided into 76 farm units, will receive their first water early in 1948. Most of the land is privately owned, but a few farms will be sold by the federal government. Another pumping plant and system of canals, which will serve 4,500 acres divided into 74 farms, will be constructed along the Snake River at Burbank, a few miles east of Pasco. Both these small units will ultimately be supplied with water from the main distribution system of the Columbia Basin, and their pumping plants will then cease operations.

SETTLEMENT

The Bureau of Reclamation has made very complete plans for the settlement of the area included in the Columbia Basin Project. In order to demonstrate methods and crops suited to the local conditions, a number of experimental and demonstration farms have been established in several parts of the project and on different soils (Fig. 4). Various methods of

applying water will be tried, and the most desirable frequency and duration of applications of water investigated. Proper leveling, layout of ditches, and erosion control will be demonstrated. Various fruits, vegetables, and field crops will be tried out. Machinery will be tested, and its efficiency and adaptation to local conditions determined.

The land has been classified into three general groups. Land of Class 1 has deep, loamy soil, and slopes not exceeding five per cent. It is suited to the production of irrigated row crops, such as potatoes, sugar beets, and truck crops, and of alfalfa. Land of Class 2 has less deep and fertile soil, or slopes up to 10 per cent. Class 3 includes inferior land, mostly suited to hay and pasture. Farm units as laid out by the Bureau of Reclamation are often irregular in shape, and one unit may include all three classes of land. It is estimated that there will be about 25,000 farm units in the project.

Ninety per cent of the irrigable land is privately owned. No land is available for homesteading. Settlers will buy land from the present owners, or from whatever non-profit agency may be formed for the purchase, layout, and resale of the land. Present owners of land in the project will be allowed to retain one family-sized unit, up to 160 acres. Land owned in excess of the family unit will not be eligible for delivery of water unless it is first sold to the federal government. The price of land is based on its worth as desert land; the value of most of it is between five and ten dollars per acre. Land suited to production of wheat under dry-farming methods has a market value that ranges upward to \$30 per acre. All land in the project is subject to restrictions aimed to prevent speculation. Land may be bought or sold only after it has been appraised by the Bureau of Reclamation. New settlers are not encouraged to buy land until the time when water can be delivered.

Construction costs for irrigation are expected to average \$85 per acre. No charge for repayment will be levied during a development period of about ten years. Costs will then be amortized over a period of 40 years. The cost of Grand Coulee Dam will be met by the sale of power in less than 50 years. The cost of the entire project has been estimated at approximately \$400,000,000, of which the sum of \$262,000,000 has been allocated to power. Experience shows that a settler should have between \$5,000 and \$10,000, or its equivalent in implements and live stock, to make proper use of the average farm unit. It is expected that water can be delivered to a part of the area by 1950.

Settlers will receive, from appropriate agencies, assistance in the production and marketing of their farm products. Settlement of the project will not be done at random, but will proceed by selected units over 25 or more years. Such a procedure will make possible the orderly establishment of means of transportation, market towns, schools, and other facilities, as the several parts of the project are made available, and will obviate the hardships associated with pioneer settlements in the past. It is expected that 125,000 to 150,000 persons will live on the approximately 25,000 farm units in the area, and that probably twice that number will be engaged in business and service occupations in the supply towns and market centers scattered through it. At a reasonable estimate, the Columbia Basin Project will add a half-million people to the population of Washington in the next 50 years.

TREES AS CLIMATIC INDICATORS

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THE CLIMATIC record afforded by tree growth has been discussed in geographic literature in the United States over a period of 30 years. The discussion began with Ellsworth Huntington, who was interested in tree growth as a support for his thesis of climatic change (1). Later studies, published by the American Geographical Society and the National Geographic Society, have applied the data of tree growth to the dating of Indian ruins in the Southwest and to the formulation of rainfall indices for this and other areas.

Because the names of several authors are associated with the literature of tree growth, the casual reader is not always aware of similarities in the techniques used in the studies it reports. The impression is easily gained that each study is an independent confirmation of the climatic significance of trees. Instead, it is the technique evolved by A. E. Douglass, of the University of Arizona, that has been followed in every instance; indeed, nearly all the laboratory work, including the final preparation of graphs showing rainfall indices, has been done by Douglass and his staff. This statement applies not only to geographic writings, but also to nearly all tree-ring studies published in the United States.

It is evident that additional perspective is required if the climatic significance of trees is to be defined accurately. Such perspective may be gained in part from pertinent studies in plant ecology; the relation between tree growth and environment is so poorly understood, however, that such studies do not provide a basis for conclusive judgment. Part of the difficulty of applying botanical evidence to the results of tree-ring analysis arises from the fact that botanists and foresters have usually studied the normal or representative habitat, whereas the trees found most useful in tree-ring analysis occupy distinctly non-representative sites. Additional checks may be supplied by other forms of historical data, such as meteorologic observations, records of fluctuations of lake levels, and descriptive literature. Such data are most abundant from the last century; they are almost completely lacking from earlier times. Archeologic stratigraphy provides some checks on the prehistoric record, but by defining sequences rather than by establishing precise dates. Most of the record of tree growth, therefore, lies beyond the range of a scientific check. It follows that only meager tools are available for evaluating it.

This fact undoubtedly explains the controversial nature of the critiques of tree-ring analysis. I shall attempt here to discuss only those aspects of the subject that pertain to the final result of tree-ring study, namely the climatic record. Considerations of minor importance will be ignored. Since I approach the question from the field of climatology, my knowledge of tree-ring analysis is based essentially upon published materials rather than on personal experience. The publication of views thus arrived at seems justified by the fact that geographic literature contains little commentary on the climatologic value of tree-ring records.

The following paragraphs give a summary of A. E. Douglass' accomplishments written by one of his most active disciples:

"When A. E. Douglass began in 1901 his classic studies in tree-ring analysis he was seeking to read and interpret what the trees had been able to record of solar and climatic changes. It was soon established that where there is a dominating climatic element which conditions growth, properly located trees respond faithfully to the changes in this element. Thus, in the arid southwestern United States, the relation between annual tree-growth and rainfall is very close, the correlation coefficient for the last century averaging 0.80. In the last two decades, studies have been chiefly directed along two paths: (1) the development of long climatic chronologies in tree growth, and (2) the analysis of these for long-period climatic fluctuations.

"Two major chronologies have now been established: (1) a continuous annual record almost 3,250 years in length derived from the long-lived *Sequoia gigantea* of east-central California, and (2) a record extending back to 11 A.D. representative to an especially high degree of rainfall fluctuations during this long period, based on the sensitive but shorter-lived conifers of northern Arizona and New Mexico. This latter series, the Central Pueblo Chronology, resulted from the successful fitting together of numerous specimens obtained from the timbers of Indian ruins, incidentally making possible the assignment of precise dates to the construction of these ancient dwellings. In addition, about a hundred shorter tree-ring chronologies have been developed for other regions of the Southwest, and for other parts of the world" (2).

Since 1934 much of the work done at Douglass' laboratory has been reported in the *Tree-Ring Bulletin*. An important study published elsewhere (3) is an investigation of the hydrology of the drainage basin of the Colorado River.

Annual rainfall is the climatic factor emphasized in Douglass' work. To judge from statistical correlation, the effect of temperature on tree growth in the Southwest has been slight (4). The same statistical technique indicates, however, that in sub-Arctic regions temperature has exerted a stronger influence.

The thesis of tree-ring analysis of Southwestern conifers is that in properly selected trees thick rings record wet years, thin rings dry years. By plotting the thickness of successive annual rings on a time scale keyed to some known date, a graph results that is held to be analogous to a graph of yearly totals of rainfall. In illustration of this analogy, curves derived from tree-rings are compared with curves drawn from instrumental records of precipitation. Such a comparison is, of course, possible for only a fraction of the time span covered by the longer tree chronologies.

Much of the following discussion will be devoted to consideration of the relative accuracy of the functions entered upon the graphs. The following questions require consideration: If ring thicknesses are assumed to be a true measure of annual rainfall, how accurate is the time scale afforded by these growth increments? And if the time scale is assumed to be correct, how accurately does the thickness of the annual growth increments correspond to annual rainfall totals?

TREE RINGS AND THE TIME SCALE

The accuracy of the time scale afforded by trees is contingent upon the accuracy with which annual growth increments can be recognized in

the "ring" structure seen in transverse section, as in a stump. The assumption that one year can be counted for each ring does not suffice, since more than one increment of growth may have been added in some years, and none at all in others. Tree-ring workers depend upon examination of cross sections under magnification to reveal differences between true annual growth layers and other layers. Missing rings, when they are detected, are observed as growth increments appearing in some trees but not in others.

Indisputable evidence for determining the degree of error in tree-ring chronologies is not available, since there is no way of determining the date at which a given tree started to grow. According to Schulman, "proper analysis of tree-ring records involves the *precise* solution of all problems of identification of non-annual or 'false' or 'double' rings, locally-absent rings, injury rings, and many other anomalies of growth" (5). In view of the known complexity of the process of growth, it is not likely that most botanists will agree with Schulman that it is possible to attain this objective.

That these complexities inevitably make it difficult to recognize the annual arrangement of woody layers can be understood when it is realized that periods of inactivity may occur at any time during the normal growing season (6), and growth be resumed only when conditions again become favorable. Such interruptions of growth have been described by Haasis, who observed the responses of Monterey pine and coast live oak in California to irrigation after growth had stopped in the dry summer (7). Glock has examined branches of trees growing in western Texas, where late spring frosts are sometimes severe enough to produce "frost rings"; by comparison of these injury rings with meteorologic data, the dates at which they were formed have been identified with a high probability of accuracy (8). Glock has found as many as five growth layers formed within one year; and has stated that except with the aid of the dated frost injuries these growth layers cannot be distinguished from those that have been produced by a single annual growth impulse. MacDougal has called attention to still another difficulty: namely, that trees standing close together may present quite different ring patterns (9).

MacDougal's statement calls attention again to the difficulty of recognizing missing rings. Since tree-ring workers practise a rigorous selection of trees on the basis of similarity (the practice of cross-dating), it is logical to assume that by such selection they are discarding just those specimens that might contain growth layers missing from the group accepted. This defect can be remedied only by increasing the size of the sample studied, and makes tree-ring chronologies constantly liable to revision.

Other causes for revision may rest upon the assumptions that have been necessary if burnt timbers, or timbers partially destroyed, were to be used. Gladwin has noted that certain dates assigned to Indian ruins by tree-ring techniques required the reversal of established cultural sequences in the archeology of northern Arizona. Reluctant to accept these dates, Gladwin reexamined the samples used by Douglass' staff, and found it possible to assign dates in accordance with the results of archeology (10, 11). The difference between his results and those originally announced rests upon differences in methods of correlating individual specimens with a master sequence. That there is room for disagreement on this point can

be seen when it is realized that perfect cross-dating among individual specimens cannot be expected. If there are different degrees of dependability in cross-dating, the identification of a single specimen with a master sequence becomes a matter of determining the best fit, and this procedure is not an exact one.

It may be concluded that chronologies established from tree-rings are suspect of error. The amount of this error cannot be generalized upon at this time other than by saying that its magnitude is probably greater in some chronologies than in others. Even with the most readable materials, however, a certain degree of error may be present because of the difficulty of identifying the grouping of growth layers into annual units. Comparisons between ring thicknesses and rainfall reveal general similarities in trend, and indicate that major maxima and minima are in agreement within a tolerance of a few years. Hence there are probably no large systematic errors in the tree-ring calendars for the past 50 years. As the calendars are keyed to the contemporary era, it is logical to expect that the effect of recession in time is to cause accumulation of calendrical error.

TREE RINGS AND ANNUAL RAINFALL

Attention will now be directed to the relation between tree growth and annual rainfall. Only the direct form of this relation has been sought by Douglass; that is, the relation in which more annual growth has taken place in wet than in dry years. Trees that exemplify this relation are found in exceptionally dry sites, on steep slopes, and near the dry margin of the forests. Their growth increments display pronounced differences in thickness; such differences define the property of sensitivity. Trees whose ring structures fail to show sensitivity are thought to be well watered and therefore unsuitable for study.

The site factors associated with sensitive trees are so exceptional from an ecologic viewpoint that little insight can be gained from studies of normally situated trees into the processes by which sensitive trees have grown. MacDougal's detailed observations of tree growth, carried out by means of the dendrograph, have failed to show a simple relation between annual growth and annual rainfall (12). So far as I know, no dendrographic records have been made of trees whose growth layers satisfy the requirements of Douglass' approach. Such a record might help to dispel the ecologic mystery that at present surrounds the growth of trees selected for tree-ring analysis.

Even when trees are selected on the basis of sensitivity and similarity, the preparation of a meaningful graph of ring thicknesses entails a major task of interpretation. Sensitivity, in the ideal case, connotes a quantitative relation between tree growth and rainfall. In the simplest form of this relation, tree growth would be doubled if rainfall were doubled from one year to the next; and all changes in the rainfall of successive years would be matched in like degree by changes in annual tree growth. Because of the effects of age, however, equal growth stimuli do not in fact produce uniform responses in growth through the life of a tree. It follows that the climatic factor assumes a variable relation to growth accomplished. The growth of a tree is an increase in volume. When the thickness of growth layers is used as an index of growth, a progressive thinning of rings toward the periphery of a cross section is to be expected, since each successive

increment of growth is deposited over a greater area than were the earlier increments. Hence if one starts with measurements of thickness of rings, a good deal of manipulation is required if one is to infer the relative strength of growth stimuli (annual rainfall) when earlier and later stages in the life of the tree are compared.

In practice the problem is still more complex, since sensitivity is a relative rather than a fixed property of growth. Some trees are much more sensitive than others, and despite careful selection by cross dating, identical degrees of sensitivity cannot be expected. Considerable differences in age are encountered, as well as differences in absolute size. It is not surprising that Glock has stated that the reduction of thickness of rings to an absolute standard is impossible and that comparison should be limited to rings immediately adjacent to one another (13). This limitation reduces the significance of comparisons of the magnitudes of maxima and minima of growth widely separated in time. Some of the significance might be restored by publication of an adequate explanation of the procedures by which ring thicknesses measured in trees differing in age, size, and innate characteristics of growth are brought together to furnish the growth in millimeters shown in the final graphs.

If inspection is directed chiefly toward a comparison of the thicknesses of adjacent rings, a simple form of trend analysis may be performed by determining whether or not ring thickness and rainfall change in the same sense from one year to the next. Thus, if a given year is succeeded by one with more rainfall, a parallel trend in tree growth would be indicated by a greater thickness in the ring deposited in the second year. Glock analyzed four tree-ring studies in this manner, and found that the two terms move in opposite directions in almost as many years as they move in agreement (14). If more recent studies are examined in the same manner, some improvement is found. Tree growth at Mesa Verde agrees in trend with rainfall at Durango, Colorado, in 32 years out of 40. The Douglas fir at Mesa Verde is said to possess superb sensitivity. In southern California trees, the agreement is not so good; trees growing in the San Jacinto Mountains show agreement with rainfall at San Francisco in 56 cases out of a possible 91. Tree growth in the Okanogan Valley, Washington, agrees in trend with local precipitation in 21 cases out of a possible total of 31 (15).

It is evident that the most favorable case for correspondence between tree growth and rainfall admits considerable imperfection. Some of this imperfection may be attributed to the questionable basis of comparison afforded by trees and rain gages when they are separated by distances measured in miles, and having different exposures and elevations. Probably the major cause of disagreement is related to the existence of growth stimuli that are not related to annual rainfall. In the best examples, tree growth is parallel to annual rainfall in a majority of years, but other factors prevent perfect correspondence. Difficult as it may be to make a strict comparison between the two measurements, a rainfall record estimated from tree-ring measurements seems to be less accurate than a calendar constructed from the same measurements. In other words, tree-rings yield a better calendar than a measure of climate.

I have mentioned earlier the reasons for presuming that as one goes backward in time there is a certain accumulation of error in tree-ring

calendars. For somewhat different reasons, a conservative view would also attach less climatic significance to fluctuations in tree growth accomplished centuries ago than to more recent growth. Since the chief purpose of tree-ring studies is to furnish indications of climate prior to the era of instrumental observations, the problem of evaluating ancient trees as measures of climate deserves attention.

It is well to keep in mind that in terms of physiologic processes a great gap exists between rainfall striking the ground and tree growth. That rainfall is important to plant life is a truism, but all ecologic evidence points away from a theory of continuous control of growth by a single factor of the environment, particularly if that factor is expressed by a single term. Limits of tree growth appear to be susceptible to definition by expressions that are simple compared with the terms involved in active growth. Unfortunately, however, no more investigation has been made of the limiting factors of growth in the exceptionally dry sites occupied by the trees typically used in tree-ring studies than of the more complex ecologic factors. In order to make due allowance for the indirect link between rainfall and growth, and for the consequent introduction of other interacting factors, Glock has suggested that the correspondence between annual tree growth and annual rainfall, where it has been discovered, reflects no more than a situation in which the single term annual rainfall happens to represent the larger effects of all growth factors combined.

If Glock's suggestion is valid, the factor of annual rainfall is in itself only an indicator of growth control, and perhaps a rather small component in comparison with the total of all other factors. Changes in site factors would almost certainly destroy the happy alignment of annual rainfall with the larger term of which it is a part. Secular changes in climate, as well as physical changes in the forest and the forest floor, require consideration. Glock draws the following conclusion:

"It seems abundantly clear, first, that temperature and rainfall are of great importance to tree growth, second, that under a certain combination of interacting factors in certain localities rainfall and temperature have such an influence on physiological processes as to bring about a degree of similarity at times in the fluctuations of tree growth and rainfall or temperature, and third, that correlations, even were they of high degree, do not permit the derivation of past or future rainfall" (16).

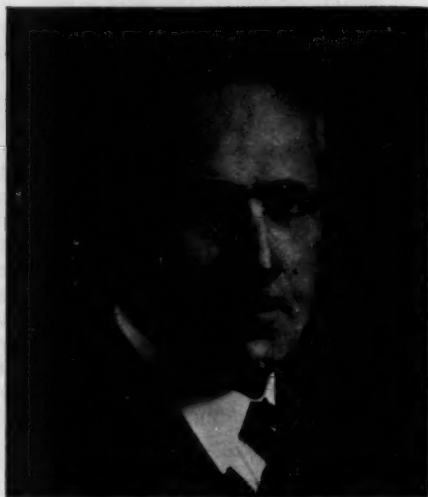
An evaluation of tree-ring studies made according to Douglass' techniques would not be complete without emphasis on the strict care exercised in the selection of the trees that are now held to measure climatic effects most accurately. This selection can be justified, in the eyes of many, only if different investigators succeed in reaching the same results independently. Gladwin's work, cited earlier, has demonstrated that different dates may be arrived at by the use of identical trees. Davis and Sampson, following Douglass' criteria in selecting specimens in the field, were unable in the laboratory to find agreement between tree growth and rainfall (17). Fry and White, on the basis of long study of *Sequoia gigantea*, maintain that these trees are affected adversely in their growth more often by too much precipitation than by too little (18). Antevs, a thorough student of tree-ring methods, selected his specimens in the field and sent them to Schulman and Hale for analysis, who used 27 out of 100 samples. The final curves permitted only somewhat conditional conclusions (19). Samp-

son and Glock have commented on the desirability of establishing cross-dating quality upon an objective basis rather than from memory (20). This and many other improvements will be needed before Douglass' methods are verified.

The climatic significance of trees appears to be best regarded as a general rather than a precise matter. In the present state of knowledge, not all of the limitations that make advisable such a broad approach can be advanced or defended with exactitude. Certain qualifications are attached to the mechanics of tree-ring analysis, and in this regard relatively rapid progress may be expected. Advance may also be foreseen as a result of further incorporation of the data of archeology and related fields. When combined with other data, the tree record may provide details within a framework that would otherwise lack continuity. Above all, fundamental research in plant growth may be expected gradually to supplant relations now established only by correlation with a more intimate understanding of the manner in which climatic factors affect the growth of trees.

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Eliot Grinnell Mears, 1889-1946

ELIOT MEARS, who was elected president of the Association of Pacific Coast Geographers in 1942, and who, with the other officers elected in that year, remained in office through the war, died of a heart attack on May 26, 1946, in Middlebury, Vermont. At the time of his death he was spending a year's sabbatical leave from his duties at Stanford University.

Professor Mears was born in Worcester, Massachusetts, February 1, 1889. His academic career began at Harvard, where he received the degrees of B. A. in 1910 and M. B. A. in 1912. From 1912 to 1916 he was secretary and instructor in the Harvard Graduate School of Business Administration. During the next four years he was in the Middle East, in the service of the United States Department of Commerce and of economic missions to countries in Asia Minor. He came to Stanford in 1921, and became professor of geography and international trade in the Graduate School of Business at Stanford when that School was established in 1925. He remained in that position until his death, in addition serving the university as director of the Hoover Library and of the summer quarter.

The list of institutions and organizations in which Professor Mears furthered the causes of scholarship and inter-

national cooperation is a long one; it includes the Institute of Pacific Relations, the Institute of World Affairs, the Council on Foreign Relations, and the Pan-American Institute of Geography and History. In 1929 and 1930 he lectured at a number of universities in Europe and the Near East. He received recognition in the form of membership in many learned societies, American and foreign, an honorary degree from Grinnell College, and the Order of the Redeemer from the government of Greece. His most important writings are *Modern Turkey*, 1924; *Principles and Practices of Cooperative Marketing* (with M. O. Tobriner), 1926; *Resident Orientals on the American Pacific Coast*, 1927; *Greece Today*, 1929; and *Maritime Trade of Western United States*, 1935. His *Pacific Ocean Handbook*, 1944, became familiar to thousands of service men and civilians during and after the second world war. In the last year of his life he was working on the manuscript of a book to be called *The Economics of Geography*. Unfortunately this work was not sufficiently near completion at the time of his death to justify publication.

With Eliot Mears' untimely death the Association has lost a helpful member and officer, and his academic colleagues a genial associate. Peace to his ashes!

THE ASSOCIATION OF PACIFIC COAST GEOGRAPHERS

Ninth Annual Meeting, Seattle, Washington, September 20-21, 1946

After a four-year interruption, the ninth annual meeting of the Association was held at Seattle, Washington, September 20 and 21, 1946. Three half-day sessions for the presentation of papers were held in room 401, Social Sciences Building, University of Washington, in the forenoon and afternoon of Friday, September 20, and the forenoon of Saturday, September 21. Because of the death of the President, Eliot Mears, the Vice-President, John B. Appleton, became President and presided at these meetings. He delivered the presidential address at the annual dinner, which was held in the Meany Hotel, Seattle, on Friday evening, September 20.

Program, with Abstracts of Papers Presented

(Papers published in full in the foregoing pages are not abstracted here.)

FRIDAY MORNING SESSION, SEPTEMBER 20:

Plantation Agriculture in the New Hebrides. MICHAEL MCINTYRE, University of Washington, Seattle.

Abstract: Three plantation products, copra, cacao, and coffee, account for 95 per cent of the value of exports from the New Hebrides. These three crops have achieved preponderance in the economy of the islands through a process of elimination of others cultivated in the past, notably cotton and rubber. Plantations vary greatly in area, but in operation differ principally in the degree to which production is restricted to one or the other of the three main crops. The French planters display more inclination toward diversification of their production than do the British.

A profile inland from the shore, near which most of the plantations are situated, provides a sequence of sites appropriate to the three principal crops. Near the shore is the sandy soil and high water table required by the coconut palm, and farther inland are the loamy soil and the shade of forest trees that are suitable for cacao and coffee.

Drying is a conspicuous part of the preparation for market of all three of the main plantation products. The devices used in the New Hebrides for drying copra and cacao and coffee beans are rather crude, so that the marketed products are not of the first quality. Coconut husks are the fuel used in all the dryers.

Conditions with respect to plantation labor are extremely unsatisfactory for both laborers and owners. Ruthless exploitation of native labor in the past

makes the natives reluctant to accept employment on the plantations. The native population, moreover, is diminishing. Both British and French planters have appealed to their respective governments for permission to import labor from Asia. The British government has steadfastly refused to allow such importation, but since the early nineteen-twenties Tonkinese have been brought from Indo-China to work on French plantations. These Tonkinese are kept in peonage, which is enforced by the local administration. The labor supply thus provided gives the French planters an advantage over their British fellows, and in consequence their number is increasing in relation to the British.

Midway Islands. ESTELLE RANKIN, University of Washington, Seattle.

Abstract: The Midway Island group is an atoll, the surrounding reef of which has the form of a rounded triangle five to six miles across. There is a wide breach in the reef on its northwestern side, and a narrow one on the south. The two islands proper in the group, Sand Island and Eastern Island, lie close inside the reef on the southern side of the atoll. Sand Island is about two miles long and one mile wide, and has an area of 850 acres. Its highest point is about 43 feet above sea level. Eastern Island, which lies about one and one-half miles east of Sand Island, has a triangular outline, is a little over a mile in length and three-fourths of a mile wide at the base. It contains about 328 acres, and is somewhat lower than

Sand Island. The surfaces of both islands originally consisted of sand. Welles Harbor, in the southwestern part of the area enclosed by the reef, west of Sand Island, originally had a depth of about 14 feet.

The United States took formal possession of the Midway group in 1867. It became a cable station in 1904, thereby acquiring as permanent inhabitants the personnel of the station. The station personnel began immediately to modify the surface of Sand Island, which was originally almost bare. Soil was brought from Hawaii, and grasses and trees planted, the former to bind the sand and the latter to serve as windbreaks. Cows and donkeys were introduced. In time, the cultivated flora has been enriched by a wide variety of useful and ornamental plants, from both tropical and middle latitudes.

In 1935 Midway became a station on the trans-Pacific route of Pan-American Airways. Pan-American's installations, built at the northeastern end of Sand Island, include shops, a warehouse, a power plant, water tanks, and a modern hotel. The United States Navy established a station at Midway in 1941. These establishments, and the limited area of land in the group, fix the character of the islands for the foreseeable future: a stopping place for air traffic, both civilian and military, in the middle of the Pacific.

Geographic Regions of Java. WILLERT RHYNSBURGER, Indiana University, Bloomington, Indiana.

Abstract: Within the three rather uniform divisions of West, Middle, and East Java, the following ten regions are suggested by the relief and use of the land:

Alluvial Lowlands

1. Northern Lowland, West Java. This plain, which averages about 25 miles in width, consists of sediments, derived from the mountains to the south, that have been deposited in the Java Sea. It contains the largest area of rice *sawahs* in Netherlands India.

2. Northern Coastal Plain, Middle Java. A much narrower plain than the foregoing. It has an appreciable dry season, which has permitted it to become one of the leading sugar districts in Java.

3. Southern Coastal Plain, Middle Java. Here there is no dry season, and hence there is much less cultivation of sugar cane than in the Northern Coastal Plain. Rice is the principal crop; the

sawahs extend in tongues far into the hills.

Valleys

4. Intermontane Valleys, West Java. A series of latitudinal valleys between the central and southern mountains of West Java, at elevations between 1500 and 2500 feet. They support a dense population based on *sawah* rice and a great variety of vegetables and fruits.

5. Rice-Sugar Valleys, East Java. Deep river valleys separate the volcanoes of East Java. Their fertile soil is used for the intensive cultivation of rice and sugar, the combination of crops that supports the densest population in Java.

Hill Regions

6. Northern Foothill Zone, West Java. This region lies south of the lowland of West Java. Poor residual soils support only grass and scrub, except for small stands of teak.

7. Northwestern Limestone Region. A broad, rolling hill zone that occupies the northern half of East Java. It is largely covered by deciduous monsoon forest, predominantly of teak. Crops are mainly poor upland rice and corn.

Highlands

8. Central Mountains. These mountains, whose summits range from 7000 to 10,000 feet in height, extend through West and Middle Java as far as the Merapi, and contain most of the rubber estates of West Java.

9. Southern Highlands, West Java. A plateau lying between 5000 and 6000 feet above sea level, surmounted by occasional higher peaks. The region is dominated by two estate crops: tea and cinchona.

10. Volcanoes of East Java. These mountains are isolated, not parts of a continuous chain. Their southward-facing slopes are well watered, and have interplanted coffee and rubber to an elevation of 2000 feet.

Land Ownership in Hawaii and Its Influence on the Local Economy. FRANCES M. EARLE, University of Washington, Seattle.

Abstract: In Hawaii land ownership is concentrated in the hands of a few people. Ten owners, each having 5000 acres or more of land, control 28 per cent of the total area, and the 100 largest owners control 47 per cent, or nearly one half, of all the land. In practice, individual ownership is reduced to a minimum, and land is generally available only through lease. Many business structures, private houses, coffee farms, and sugar plantations occupy leaseholds for which annual rentals are paid.

For almost a century, sugar has been the chief crop of the islands, and has dominated trade. Access to the United States market stimulated the development of sugar plantations, and thereby created an unprecedented demand for labor. Waves of contract laborers came from Japan, China, and various islands in the western Pacific, and a feudal system of labor relations was firmly established. Pineapples now share with sugar the leading position in the production and trade of the islands.

Hawaiian economy, primarily agricultural, is poorly balanced because of the great emphasis on the production of sugar and pineapples on plantations. Other cash crops, such as coffee, are grown by farmers on small tracts of leased land. The commercialization of agriculture, as well as the necessity of paying rent in perpetuity, tends to discourage both diversification and the growing of a food supply adequate to meet normal local demands.

A large group of landless workers and a smaller landed aristocracy are supported by the highly specialized plantation system. Closer settlement based on the redistribution of land would aid in solving such serious social and economic problems as a tenancy rate of 70 per cent and increasing technologic unemployment.

Denver: an Urban Analysis. HOWARD H. MARTIN, University of Washington, Seattle.

Abstract: Situated at the boundary between two of the major relief provinces of the United States, Denver is the metropolis and regional capital of the southern Rockies and the most productive part of the Great Plains. In contrast with many other American cities comparable in size, Denver depends upon a hinterland that is enormous in area but sparsely populated. This dependence tends to be direct, as is indicated by the following list of major sources of income, which are arranged approximately in the chronological order of their influence in Denver's economic life:

1. **Mining.** The mines are largely in the southern Rockies. Returns to Denver come from the manufacture and sale of mining supplies and machinery as well as from investments in mining stocks.

2. **Cattle and Sheep Ranching.** The raising of live stock in the Great Plains, and to a lesser degree in the southern Rockies, has led to the establishment of slaughtering and meat-packing plants

in Denver. Meat packing, which had its beginnings in the early mining days, is now a major industry with a large payroll. Specializing in the slaughter of sheep, the city is also a wool market.

3. **Irrigation Agriculture.** Within Denver's hinterland, crops such as sugar beets, alfalfa, beans, and other vegetables and fruits are produced under irrigation, largely along the front of the Rocky Mountains. Mountain parks and benchlands add to the total. The handling and financing of these irrigation crops is mainly done in Denver.

4. **Tourism.** This is a summer business of considerable magnitude, which keeps Denver's hotels and restaurants filled during the season; its ramifications reach into many smaller resort centers throughout the Rockies. The majority of tourists come from the area that extends eastward from Denver to Chicago and the Mississippi Valley, and southward to the Gulf.

5. **The Federal Payroll.** As the largest city between the Missouri river and the Pacific Coast, Denver is the logical administrative center for a wide array of government offices. At present there are more than seventy such offices situated here. With the pyramiding of Federal agencies since 1930, the government payroll has become one of the city's largest sources of income.

6. **Retirement Money.** Many miners, livestock men, and ranchers in the tributary area, long accustomed to business connections with Denver, consider it a logical place to which to retire. Their income continues to flow in from property in the hinterland. Their number is large, and their aggregate wealth is a significant factor in the urban economy.

Conclusion. Denver's economic stability is high, since it is based on primary production of ranch, range, and mine, to which is added an annual Federal payroll as well as a seasonal income from vacationists. Since manufacture for distant and competitive markets is virtually prohibited by high costs of transportation, manufacturing is normally limited, and specialized to meet local demands. A large fraction of the people who live in and travel through Denver buy only consumers' goods. There has been no attempt to stretch industry or trade beyond these recognized limits.

San Francisco, 1846-1946. H. F. RAUP, Kent State University, Kent, Ohio.

Abstract: 1946 marks the centenary of the establishment of the English-speaking settlement on the shore of

Yerba Buena Cove. In the century that has passed since its founding, San Francisco has become one of the major ports of the west coast of the United States, particularly in commerce. The land on which the original settlement was built was in many respects unpromising as the site of a large city; the available area was restricted, transportation connections with the interior of the continent difficult, building materials scanty, water-supply inadequate, and earthquakes likely to occur at any time. These deficiencies have been overcome by a variety of devices, which range

from the leveling of high hills to the invention of the cable car and the construction of aqueducts and bridges across San Francisco Bay. The present trade of San Francisco is largely based on the overseas needs of the American armed forces, but figures from before the war show a heavy dependence on shipping to and from Great Britain and Japan. Both imports from and exports to these countries include a wide variety of commodities. The cosmopolitan character of the inhabitants of San Francisco today reflects their continued interest in trade with the rest of the earth.

FRIDAY AFTERNOON SESSION, SEPTEMBER 20:

The Evolution of an Olympic Peninsula
Timber Town: Shelton. MARGARET
CARSTAIRS, Seattle, Washington.

Abstract: Shelton lies at the head of Big Skookum Bay, one of the ramifications of Puget Sound at its southwestern extremity. The first settlement on its site was on a claim taken up by David Shelton in 1853. The town was not laid out and named, however, until 1884. In the meantime other nearby places, including Union, Skokomish, and Arcadia, had been established. The cutting of timber for sawmills on the eastern shore of Puget Sound supported these settlements, and Shelton after it was founded, well into the twentieth century.

Until 1884, the logs cut from the forests about the southwestern shores of Puget Sound and shipped from local ports were brought to the water's edge by ox teams. Shelton's history as a town dates from that year, when a logging railway was built westward along Goldsborough Creek from a terminus on David Shelton's claim. In the following decade, other railways were built to bring logs to Shelton. In spite of the ever growing demand for logs, however, the lumbering and railway enterprises became bankrupt in the early nineties. Consolidation and reorganization by outside interests following this bankruptcy separated the ownership of logging camps and railways; ownership of the various enterprises passed into the hands of two firms, the Simpson Logging Company and the Peninsular Railway Company. A newly organized "company store" became the principal mercantile establishment. By 1903 Shelton was the largest town in Mason County.

The year 1924 introduced a new period in the economic life of the town, with the establishment of two large lumber mills, a power plant, and a paper pulp

mill. Shelton was transformed from a point of transshipment of logs to a center of manufacture of wood products. Plants for the manufacture of plywood and insulating board have since been added. The most recent development in the economy of the area from which the raw materials of the town's industries is drawn is a prospective cooperative arrangement between the owners of forest land and the United States Forest Service, under which the land will eventually be placed on a permanent basis of sustained yield.

Cruising, Selling, and Growing Washington State Timber. JOSEPH T. HAZARD, State Department of Public Lands, Olympia, Washington, (No Abstract.)

Indian Fishing Rights in Washington and Their Effect on Salmon Conservation. TIM K. KELLEY, University of Colorado, Boulder.

Abstract: Because of certain treaty rights dating from 1855, neither state nor federal agencies have legal control over Indian fishing in the territorial waters of Washington. Indians are permitted to fish in reservations or "accustomed fishing places" without restraint by law or regulation. They are permitted by treaty to take the maximum of salmon needed for their own use. Today, in addition to supplying their subsistence needs, they are engaged in commercial fishing. They also freely use such gear as traps, set nets, dip nets, spears, and gaff hooks, all of which are forbidden to other fishermen.

In recent years the fish caught by the Indians has increased until it constitutes an appreciable fraction of the total catch. During the five-year period of 1935-39, inclusive, the known Indian

catch of salmon and steelhead amounted to 21,780,869 pounds. Since many catches are never reported, this figure is conservative. It also excludes an additional 1,000,000 pounds consumed as food.

Because a majority of Indian reservations are situated on spawning streams, escapements are affected. The Indians get approximately 38 per cent of the Bonneville escapement, and in some years as much as 65 per cent. Of the thousands of Chinook salmon headed for the Yakima River in 1940, just 1100, by actual count, remained after restricted commercial fishing in the lower Columbia and unrestricted Indian fishing above Bonneville.

Salmon and steelhead caught on or off the reservations by Indians for their own food supply are not regarded as a serious problem. The real problem lies in unregulated Indian fishing the year round, the use of any and all types of gear, and especially the heavy inroads made on salmon escapements to spawning streams. Unrestrained fishing of this kind may nullify conservation measures designed to provide a sustained yield for all fishermen, both Indian and non-Indian.

The Function of Water Transportation in the Alaska Salmon-Canning Industry. ROBERT N. YOUNG, University of Washington, Seattle.

Abstract: Transportation by water is a major factor in all the operations of the Alaskan salmon fisheries. The following table gives the percentages of the total pack of canned salmon in 1945 in the principal areas of canning in Alaska:

| | |
|---|-------------|
| Bristol Bay District..... | 15 per cent |
| Kodiak District | 17 per cent |
| Prince William Sound- Recreation Bay District | 16 per cent |
| Southern District of South- eastern Alaska | 13 per cent |

All the canneries are situated on deep water, so that the fish may be easily transferred from fishing vessels to the canneries and the canned salmon shipped from the canneries in oceangoing cargo vessels.

Virtually every piece of equipment used in the canneries must be shipped to them from ports on Puget Sound. Such equipment as cannot be stored at the canneries through the winter is returned to Puget Sound ports at the end of the canning season. In southeastern Alaska it is possible to ship supplies, including food, to the canneries during

the canning season to supplement those delivered before the season opens. But in remote Bristol Bay, where the fishing season lasts only one month, all supplies must be at the canneries before operations begin. Labor must also be transported to the canneries, either from the States or from nearby Alaskan ports. Air transportation now supplements shipping, but is more expensive.

Several canning companies formerly operated their own vessels, all of which were taken over by the Federal government during the war. A few of these have been returned to their former owners, but only two or three were in use by them in 1946. The industry now relies on three common carriers: The Alaskan Steamship, Alaskan Transportation, and Northland Transportation Companies.

Irrigation Agricultural Specialties in the Yakima Valley. RICHARD M. HIGGS, JR., Oregon State College, Corvallis, Ore.

Abstract: According to the census of 1940, Yakima County surpassed all the other counties of the state of Washington in value of agricultural products. It also ranked high in agricultural production among all the counties of the United States: it was first in apples and pears, third in cherries, fourth in potatoes, eighth in all vegetables and in cherries. Yet this high production has been achieved solely by irrigation from the Yakima River, in a region that receives an average annual precipitation of only 7.5 inches, less than 30 per cent of which falls in the growing season. Agriculture in the Valley is still in a state of flux; ownership of land, size of farms, and areas devoted to individual crops have not yet attained stability.

Ever since the beginning of irrigation in the Valley, fruit has been its most important product. Most orchards are planted on rolling or sloping lands, for the sake of air drainage in early spring. They therefore occupy the largest fraction of land under cultivation in the "Upper Valley," upstream from Union Gap, a few miles southeast of the city of Yakima; and in the "Lower Valley," downstream from Union Gap, on the land north of the Yakima River. Apples occupy a larger area than any other fruit; twice the area in pears, the second fruit crop in area. Most apples and pears are grown in the Upper Valley, whereas recent planting indicates a tendency to-

ward the concentration of peaches, cherries, apricots, and especially grapes, in the Lower Valley. The grapes grown are of American varieties, produced for juice, jam, and jelly; the production of this fruit is increasing rapidly.

Besides fruit, several other specialty crops occupy large areas in the Valley. The area in hops expanded rapidly in the years 1942-44, but has probably reached a maximum. The acreage in asparagus has doubled in the last decade. Fostered by government subsidies, the area in sugar beets has become large. Except for hops, which are grown throughout the Valley, the principal production of all these crops is in the Lower Valley.

The Physiography and Geography of Pend Oreille Lake. WILLIS B. MERRIAM, Washington State College, Pullman. (No Abstract.)

The Geography of State Parks; a Comparison Between Indiana and Washington. OTIS W. FREEMAN, Eastern Washington College of Education, Cheney.

Abstract: The institution of state parks arose from a desire to conserve historic sites and scenic areas not in federal preserves. Such parks also provide protection to wild life, and recreational facilities convenient to centers of population. Indiana and Washington offer an interesting contrast in the character and development of their state parks. Washington has mountains, sea coast, lakes, and extensive forests. The scenery of Indiana, on the contrary, is on a modest scale. The unglaciated

southern third of the state is hilly, and the northern counties contain many glacial lakes; but there is nothing that compares with the scenery of Washington. Yet the Indiana state parks constitute a system that may serve as a model to other states.

Indiana's system of state parks began in 1916, with McCormick's Creek and Turkey Run in the west-central part of the state. By 1946 it included 14 parks comprising 37,501 acres, and eight memorials with a total of 253 acres. During 1946 more than a million visitors paid \$250,000 in admission and other charges. The money collected is used for maintenance and improvement of the public facilities of the parks. These facilities range from hotels and museums to overnight cabins, trails, picnic tables, and swimming pools.

The first state parks in Washington were established on donated land in 1915. By 1946 there were 68, with a total area of 45,871 acres. No admission fees are charged, and few of the total number of visitors register; but the annual number of visitors is estimated at about 1,000,000. The largest of the parks is Mount Spokane Park, which includes 15,858 acres. There are several having areas between 1,000 and 6,000 acres, but 41 contain less than 100 acres each. Accommodations in the Washington parks are greatly inferior to those in Indiana. Only 35 of them, or just over half, have been "developed." These are usually provided with trails, drinking water, picnic tables, and stoves. Only Mount Spokane and Dry Falls Parks have overnight accommodations. All the Washington parks need further improvement.

FRIDAY EVENING, SEPTEMBER 20:

Annual Dinner, Hotel Meany. Address of the retiring President: Geographic Research and World Affairs. John B.

Appleton, Department of State, Washington, D. C. Published in full in this issue of the Yearbook.

SATURDAY FORENOON SESSION, SEPTEMBER 21:

Geopolitics, 1946. Joseph E. Williams, University of Washington, Seattle. (No Abstract.)

Agriculture in Tucumán, Argentina. VIOLET RYBERG, Public Schools, Seattle, Washington.

Abstract: Tucumán is the smallest and most densely settled province of the Argentine Republic. Most of its population is supported by agriculture, in

which sugar cane is the chief crop. Eighty per cent of Argentina's sugar is produced here, within an area 100 miles long and 50 miles wide. Sugar became the predominant crop only after 1876, when a railway was built northward to Tucumán and Córdoba. The acreage of sugar cane was then trebled in four years. At present more than one-half of the 250,000 acres of cultivated land in the province is devoted to cane. Sugar is produced in 27 refineries within the

province. Serious climatic risks affect the utilization of sugar cane in Tucumán. Rainfall is uncertain, and in the eastern half of the province there is danger from frost. Hence there is great variation in the yield from year to year. Argentina has had a protective tariff on sugar for many years, which is adjusted to variations in yield.

Of minor crops, corn ranks first, occupying one-fourth of the cultivated area. Several kinds of fruit, of which the citrus fruits are the most valuable, are grown in the frost-free parts of the province. Tobacco, cotton, wheat, oats, and forage crops occupy smaller areas. Cattle, sheep, goats, and mules have been reared in Tucumán since colonial times. Horses, which are used primarily for riding, and dairy cattle must be replenished from the cooler parts of Argentina.

The trade of the province reflects the predominance of agriculture. Sugar and alcohol are the principal exports, followed by citrus fruits, hides, and tobacco. The imports include mineral oil and lubricants, machinery, minerals, firewood, textiles, and wine.

Temperatures in the State of Washington as Influenced by the Westward Spread of Polar Air Over the Rocky and Cascade Mountain Barriers. T. EDWARD STEPHENS, Seattle, Washington.

Abstract: In the State of Washington, low temperatures in winter are associated with winds from easterly directions. The easterly winds arrive with cold fronts that move westward across the state, behind which polar air lowers the temperature in the area over which it advances.

Whenever the polar air moves across mountains, whether in the eastern or the western part of the state, higher temperatures are observed in it on the lee sides than on the windward sides. Only the air at the altitude of passes and ranges through or over which the polar air masses move reaches the surface on the lee side. The temperature of the air that reaches lower levels on the lee sides approximates the temperature obtained by adding to the temperature at the altitude at which it crosses the mountains the amount of adiabatic warming the air undergoes in descent on the lee side. The mountains thus contribute to the influence of the ocean in maintaining a positive anomaly of air temperature over the state of Washington in winter.

Precipitation Patterns of Eastern Washington. JOHN C. SHERMAN, University of Washington, Seattle.

Abstract: This discussion is based on a series of new maps of mean precipitation in the part of the state of Washington that lies east of the crest of the Cascade Mountains. The data used in constructing the maps are the records kept at 107 stations. All records of five years or longer were used, and were adjusted to the period 1910-1940. The maps discussed here are those of winter, summer, and annual precipitation. "Winter" and "summer" are the usual climatologic seasons of three months each.

Slightly more than 41 per cent of the annual precipitation of eastern Washington falls in winter. At this season the heaviest precipitation falls on the eastern slope of the Cascades, and the seasonal total diminishes very rapidly eastward from this zone of maximum. Winter precipitation is least in the country enclosed by the Big Bend of the Columbia River, in the vicinity of Moses Lake. Two secondary areas of heavier winter precipitation appear on the map, in the northeastern and southeastern corners of the state, respectively. Of these two, the latter receives the more precipitation.

Summer precipitation constitutes 11.5 per cent of the annual total. It is distributed much more uniformly than that which falls in winter. In the Cascade Mountains, only about one tenth as much precipitation falls in summer as in winter, whereas the driest stations receive nearly half as much as in winter. The stations that are rainiest in summer are not situated in the Cascades, but in the high country farther east, in the Okanogan Highlands in northern Washington and the Blue Mountains in the southeast. The driest areas are the same as in winter: the lower parts of the Columbia Plateau and the Yakima Valley.

The distribution of annual precipitation closely resembles that of the fraction that falls in winter, the season that contributes most to the annual total.

The Environmental Factor of High Altitude at Climax, Colorado. JOHN H. THOMPSON, University of Washington, Seattle.

Abstract: Climax, Colorado, the mining camp at which more molybdenum ore is extracted than anywhere else on earth, is situated thirteen miles north

of Leadville at an elevation of more than 11,000 feet. The circular mineralized zone, which contains more than 200,000,000 tons of ore, is more than one-half mile in diameter. The character and situation of the ore body facilitate the use of gravity and inexpensive methods of mining. The milling equipment, which is of the most modern type, handles more than 18,000 tons of ore daily. Concentrates are usually packed in paper-lined jute bags, which weigh 176 pounds when filled, and are transported on a steep narrow-gauge railway to Leadville. Here the bags are transferred by hand to a standard-gauge line for shipment to the conversion plant at Langeloth, Pennsylvania.

The problem of maintaining sufficient personnel and safeguarding the health, efficiency, and morale of the large number of employees is made exceedingly difficult by the properties of the atmosphere at the high altitude of the mine: low atmospheric pressure and the consequent low concentration of oxygen, low relative humidity, and variable temperature. Headaches, indigestion, sleepiness, nausea, and anoxia or altitude sickness lower the efficiency of unacclimatized workers, while respiratory diseases (silicosis and others) are common among those who are acclimatized. As a result, there is an enormous labor turnover. The stability of the labor force is being increased by improvements in housing, a program of hospitalization, and facilities for recreation.

The great demand for molybdenum, economies of large-scale production, limited competition, and intelligent management make possible the success of this industry, which operates under the adverse conditions associated with high altitude.

The Alaskan Taku Wind. CAROL C. BEAMER, Pan-American Airways.

Abstract: The name "Taku Wind" is applied to extremely gusty and strong offshore winds that occur along the entire coast of southeastern and southern Alaska. It was first applied to winds of this character observed in Taku Inlet south of Juneau, but has been extended to include similar winds observed elsewhere along the coast. Taku winds are associated with steep pressure gradients from northern British Columbia and Yukon Territory toward the coast. The steep gradients are in almost every instance the result of the building up of high pressure in Arctic

air inland rather than of the lowering of pressure over the Gulf of Alaska. The Taku wind is therefore a phenomenon of the cold season.

In winter there are often very large differences in air temperature between the interior and the coast; differences of 60 degrees Fahrenheit between Sitka and Whitehorse are not uncommon. As the cold air moves outward through the passes in the coastal mountains, part of it overruns the less dense maritime air along the coast, although it is denser than the maritime air. The instability thus produced is resolved by violent overturning. Gustiness is also favored by the presence of islands opposite the passes traversed by the continental air, against which its momentum carries it.

At Juneau the Taku wind blows down a deep canyon between Mount Juneau and Mount Roberts, across Gastineau Channel, and against Douglas Island. Several pilots have lost their lives flying in Gastineau Channel when the Taku was blowing. Aircraft have dropped into the channel from heights of several thousand feet. Juneau airport is so situated, however, that danger from the Taku wind may be avoided. It is eight miles northwest of the town, where the channel between the mainland and offshore islands is several miles wide, and about three miles west of the mountain front. Aircraft may approach the airport at a high elevation, say 12,000 feet, let down gradually over the wide channel, and make a relatively smooth landing.

Mountains as a Climatic Control. PHIL E. CHURCH, University of Washington, Seattle.

Abstract: Mountains, especially high continuous ranges, react on the circulation of the atmosphere in a number of positive ways such that differences in climate are produced on opposite sides of them. The more important of the effects of mountains on climate are:

1. They cause ascent of air on the windward sides. Ascent occurs when the air is unstable, or when the gradient wind is virtually normal to the axis of the range and is strong enough to carry air up the slope of the mountains.

2. They permit descent of air on the lee side. Descent on the lee side occurs only when the air crossing the mountains has a potential temperature lower than that of the air on the lee side, or when the velocity of the

air crossing the mountains is great enough to remove by turbulence and mixing the air originally present.

3. They change the direction of the wind. On the windward side the direction of the wind below the crest is changed to a direction parallel to the main axis of the range if the air is stable below the crest.

4. They act as dams. If the lapse rate on the windward side is stable, and the wind too weak to force air over the mountains, the mountain range prevents air from flowing across. The air that may then arrive at the surface on the lee side is air that was above the crest of the mountain on the windward side.

5. They lower the temperature of the air at the surface. Because of the higher

altitude, temperatures on the sides of mountains are lower than in surrounding areas at lower elevations. If the temperatures are low enough, snow that falls remains unmelted and accumulates until the temperature rises sufficiently to melt it. The snow, in turn, forms a surface that does not rise above the freezing temperature, while the surrounding air may be above freezing. This condition favors local downslope winds. Finally, the snow cover increases cloudiness when the temperature of the air is above freezing but in contact with the surface of the snow.

This discussion does not consider the effects produced by two parallel mountain ranges with a narrow valley between them, by mountains enclosing a basin, or by low gaps in mountains.

SATURDAY AFTERNOON, SEPTEMBER 21:

Business Meeting.

Tenth Annual Meeting, San Diego, California, June 20-21, 1947

In 1947 the Association resumed its summer meetings in conjunction with those of the Pacific Division, American Association for the Advancement of Science, and participating organizations. Three half-day sessions for the presentation of papers were held in Parlor C, San Diego Hotel, in the forenoon and afternoon of June 20 and the forenoon of June 21. The address of the retiring president was delivered and the results of the election of officers for 1947-48 announced at the annual dinner in the U. S. Grant Hotel in the evening of June 20.

Program, With Abstracts of Papers Presented

(Papers published in full in the foregoing pages are not abstracted here.)

FRIDAY MORNING SESSION, JUNE 20:

Localizing Vegetation Terms. A. W. KUECHLER, University of Rochester, Rochester, New York.

Abstract: In addition to terms that are suitable for use in a general classification of vegetation (see, for example, my article "A Geographic System of Vegetation," *Geogr. Rev.*, Vol. 37, 1947, pp. 233-240), many terms are used to designate the vegetation of particular areas, and which refer exclusively to those areas. The following list includes examples of such regional designations of vegetation that are familiar to most readers: Chaparral, Sage Brush, Prairie, Muskeg, Llanos, Paramo, Loma, Pampa, Caatinga, Veld, Moor and Heath, Garigue and Maquis, Puszta, Tundra, Taiga, Steppe, Terasi, and Mallee. All the

continents are represented in this list, although more of the terms are taken from the Americas than from other continents.

These terms can be sharply defined, and are exceedingly useful. Use of the general geographic classification of vegetation does not exclude the continued use of them. It is to be emphasized, however, that they should not be applied outside the specific areas to which they pertain. Accordingly, they should be capitalized in writing, as are the names of other topographic features.

Changes in the Map of the World Resulting from World War II. CARL H. MAPES, Rand McNally and Company, Chicago, Illinois. (No Abstract.)

Trees as Climatic Indicators. HARRY P. BAILEY, University of California, Los Angeles.

Published in full in this issue of the Yearbook.

Naval Administration in the Pacific. J. L. TAYLOR, Lieutenant Commander USNR, School of Naval Administration, Stanford University, California.

Abstract: The Navy has been assigned the duties of administering American Samoa, Guam, and the former Japanese Mandated Islands (American Trust Territory of Micronesia). For almost fifty years the United States has had possession of American Samoa and Guam. The Navy, which has had the task of governing these islands, has conducted affairs in them reasonably well, although it has been the target of severe criticism, some of which is justifiable.

Following American occupation of the former Japanese Mandated Islands, the Navy assumed administrative control over some 3,000,000 square miles of territory, 1400 islands and islets, and about 50,000 Micronesian inhabitants. Beset by problems of demobilization, shortage of personnel, supplies, shipping, communication, and directives as to ultimate disposition of the islands, the Navy has been rehabilitating, educating, providing health and sanitation and essential everyday items to the islanders, whose resources are limited and whose wants are few.

With the decision of the United Nations to turn these islands over to the

United States, some definite steps can be taken toward a better administration than has been possible heretofore.

Geography of Eugene and its Hinterland. WARREN D. SMITH, University of Oregon, Eugene. Read by title.

Geographical Influences Affecting the Success of Agricultural Marketing Cooperatives. ANDREW W. WILSON, Fresno State College, Fresno, California.

Abstract: In the fiscal year 1943-44, four million members of 10,000 farm cooperative organizations in the United States did five billion dollars' worth of business. Most of this business was done by farmer-owned cooperatives in marketing the product of the owner-farmers' establishments.

Among the problems related to the success of marketing cooperatives, two have geographic implications: 1, Should the cooperative be organized on a regional or commodity basis? 2, In either case, should the plan of organization be of the centralized or federated (i. e., formed by the association of local groups) type? Experience seems to indicate that it is preferable to market a single commodity by means of a cooperative of the federated type, but there are numerous exceptions.

Ultimately, each agricultural marketing cooperative must carefully consider the questions posed in the light of its own situation. A wrong decision on either choice may foredoom it to failure.

FRIDAY AFTERNOON SESSION, JUNE 20:

Land Forms and Land Use on the Eastern Shore of Monterey Bay. CHARLES NOBLE BEARD, Fresno State College, Fresno, California.

Abstract: The eastern shore of Monterey Bay displays the following land forms: 1, beaches and coastal dunes; 2, Quaternary terraces, including uplifted marine terraces adjacent to the strand line and conspicuous alluvial terraces inland; 3, slough and marsh; 4, alluvial fans; 5, low, well rounded mountains developed on soft sedimentary rocks; and 6, rugged mountains developed on resistant sedimentary, metamorphic, the igneous rocks.

The principal fruit crops are apples, grapes, apricots, cherries, and pears. The acreage of bush berries is now comparatively large. Of vegetable crops, lettuce stands first in acreage and value,

but significant quantities of artichokes, Brussels sprouts, and tomatoes are also produced. The principal field crops are grains, hay, sugar beets, and dry beans.

The beaches and coastal dunes are used largely for summer residences, recreation, and pasture; but in the dunes the area in bush berries has increased greatly in recent years. The Quaternary terraces are used mostly for hay, grain, and pasture; but small fields of berries, vines, and truck crops are becoming more abundant. Arable land of the sloughs and marshes appears to be especially adapted to artichokes, Tomatoes, beets, and lettuce also are important. The alluvial fans and flood plains contain the best land, and are used mostly for lettuce, orchards, beets, and tomatoes. The sandy hill districts provide very poor agricultural land, and are generally covered by pasture and

brush. They contain, however, some orchards and berry fields. The mountainous districts of both types have a high percentage of pasture; but in the foothills some fields are used for orchards and hay.

Expansion of the frozen fruit industry, especially since 1944, is affecting the production of many vegetables, berries, and fruits; but the use of the land is usually determined by relative productivity of the soil and fluctuations in the market value of the crops.

The Leonis Valley-Elizabeth Lake Area, a Part of the San Andreas Fault Zone in Southern California. JUNE CARROLL, University of California, Los Angeles.

Abstract: The Leonis Valley-Elizabeth Lake area occupies a twenty-mile segment of the San Andreas fault zone on the desert side of the Sierra Madre some sixty miles by road from metropolitan Los Angeles. It is separated from the Mojave Desert by the Portal Ridge. The area displays the results of both horizontal and vertical diastrophic movements. Both the northern and southern boundaries of the valley are uplifted fault blocks. The fault trace itself, however, is manifested in gradational rather than structural land forms. The valley is the result of degradation of a belt of shattered rocks in which both positive and negative displacement of minor blocks has occurred, rather than of the relative down-faulting of a single large block. Diastrophic processes have produced three prominent constituents of the area: 1, the horsts that form the bounding ridges; 2, the alluviated trough several hundred feet below their crests; and 3, fault splinters that stand up as ridges and knolls within the valley. Alluvial fans are the principal depositional forms. Disturbance of drainage by faulting is indicated by the presence of wet meadow land and sag ponds.

Since it afforded water and grass, the valley was historically the site of an important route leading from the Great Valley of California to a junction with the Spanish Trail at Cajon Pass. The present main road through the valley lies on the northern side of the trough. Farmers in the valley use the long detrital slope from the higher, wetter Sierra Pelone block on the south for diversified agriculture, most of the moist valley bottom for pasture and hay, and the better drained slopes and margins of the alluvial fans for orchards and vineyards. Rolling land is planted to wheat and barley. In Hughes

Lake the valley contains one of the few mountain-bordered lakes within easy driving distance of Los Angeles, and this lake has been the scene of some development of recreational facilities.

Preliminary Climatological Study of the San Joaquin Valley. DAVID PONTIUS and DORIS WEAVER, Fresno State College, Fresno, California. (No Abstract).

The Rainiest Month in California. JOHN LEIGHLY, University of California, Berkeley.

Abstract: Either of two procedures may be used to identify the rainiest month from the record of precipitation. First, one may examine the means of monthly precipitation, making allowance for the inequality in length of the months. Second, one may look through the successive years of the record, and count the number of times each month has been the rainiest in particular years. When applied to California, the results yielded by these two methods are not identical, but agree in general. In the northwestern corner of the state December is the rainiest month. In the remainder of the state north of the latitude of Lake Tahoe, and in the Coast Ranges southward to San Luis Obispo, January is the rainiest. February is rainiest in a large area that includes the Coast Ranges of Southern California, most of the Great Valley, and the western slope of the Sierra Nevada. East of the Sierra and in the Mojave Desert the peak of the rainy season shifts back to January, and still farther back to December in Imperial Valley and along the Colorado River.

The dates of the peak of the rainy season given above are determined by examining the records for the 40 years ending with the season 1944-45. Longer records show that the distribution of precipitation through the winter has not been at all stable. Means computed for a period of comparable length ending in 1930 show January as the rainiest month over most of the state, including the large area in which the last fifteen years of record shift the peak to February. Several of the stations in this area show, in fact, that in the average of records ending at about the beginning of this century December is as rainy as January, or even rainier. There has thus been, over central California, a distinct shift of the rainiest part of the winter in the past fifty years, a shift that amounts to nearly or quite two months. The fluctuations in precipi-

precipitation in California within the period of record thus involve not only the seasonal amounts of precipitation, but also its distribution through the rainy season.

Regional Basis for Population Increase of the Corvallis-Albany Urban Center. J. GRANVILLE JENSEN, Oregon State College, Corvallis.

Abstract: Corvallis and Albany, Oregon, constitute a two-point urban market center for the Willamette Valley between Salem and Eugene. In the past few years both towns have grown significantly, but unequally: since 1940 the population of Corvallis has increased 37 per cent, while that of Albany has increased 109 per cent.

The regional basis for the support of urban centers favors Albany more than it does Corvallis. Five factors appear to explain the disproportionate growth of Albany as compared with the more normal increase in the population of Corvallis:

1. Albany is favored by its domination of the wider valley bottom.
2. Agricultural resources tributary to Albany, measured by quality of soils and actual production on farms, are three to four times as large as those tributary to Corvallis.
3. Forest resources tributary to Albany are perhaps ten times as large as those tributary to Corvallis.
4. Albany is favored by its situation on the main railroad and the principal branch of the motor highway through the region.
5. There seems to be more active promotion of industry by business men in Albany than in Corvallis.

Thus the more rapid growth of population in Albany may be ascribed primarily to a hinterland more generous than that served by Corvallis. Both towns may be expected to continue their growth in the near future. The presence of a large state college in Corvallis is a factor of economic stability that Albany does not possess. It is clear, however, that the future of both towns depends inexorably on healthy activity in forestry and agriculture, since both are in large measure dependent on the resources of forest and soil.

The Columbia Basin Project. ORIS W. FREEMAN, Eastern Washington College of Education, Cheney.
Published in full in this issue of the Yearbook.

A Geographic Approach to Some Technical Problems of Commercial Aviation. HOMER ASCHMANN, San Diego State College, San Diego, California.

Abstract: A geographic approach might contribute valid solutions to some problems of commercial aviation. For example, the microclimatologic problem of locating airfields so as to minimize periods of poor visibility is of vital concern in many metropolitan areas. Knowledge of the frequency of occurrence of visibility within critical limits requires detailed observations that are normally unavailable except at major airports. A careful assessment of the features of the terrain that affect visibility at several airfields in a given climatic province should provide a theoretical basis for the choice of sites for airfields when adequate meteorologic observations are lacking. With the development of aircraft that operate most effectively at high altitudes, the accurate plotting of direction and speed of stratospheric winds at different elevations assumes an importance comparable with that of the plotting of surface winds in the days of sailing ships. A study of airport construction in different climates might lead to the identification of satisfactory methods of construction that small or poor localities can afford to maintain. The minimum distance from the center of a city at which an airport can be constructed so as to take full advantage of rapid transportation without prohibitive costs is a significant problem in urban geography. The military experience of the Air Transport Command may provide a guide to the selection of the best designs of aircraft for use in climatically difficult regions, such as desert, selva, and tundra.

As aviation ceases to be a luxurious novelty, commercial air lines are forced to scrutinize their competitive position in relation to other forms of transportation. This position varies regionally, and the study of it seems to lie near the core of economic geography. It would seem possible to divide the earth into potential air transportation regions such as: 1, regions where there is good surface transportation and air transport merely pits speed against lower costs; and 2, regions where surface transport is poor or lacking. The status of transportation in the latter class of regions may be transitory or permanent, but it is in such areas that commercial aviation can make its greatest relative contribution to the local economy.

FRIDAY EVENING, JUNE 20:

Annual Dinner. U. S. Grant Hotel. Address of the retiring President: Snow as an Environmental Factor in the

West. PHIL E. CHURCH, University of Washington, Seattle.

Published in full in this issue of the Yearbook.

SATURDAY FORENOON SESSION, JUNE 21:

Problems of Recreational Use of Lake Elsinore, California. ROBERT W. PEASE, North Hollywood High School, North Hollywood, California.

Abstract: At Lake Elsinore in southern California an attempt has been made to use for recreational purposes a lake that varies from year to year not only in size, but also in recreational appeal. The town of Elsinore, which is primarily dependent upon recreation, faces serious business shutdowns when many permanent residents are forced to leave as recreational activity declines. Several attempts have been made to subdivide land into lots for sale as sites of houses and cabins. This land has suffered tax delinquency as high as 90 per cent when the lake almost disappeared. Tax delinquency injures the community, and subdivision has reduced the potentialities of the area by removing agricultural land from productive use.

Since the lake overflows only infrequently, its area depends upon a balance between water supply and evaporation. Direct rainfall amounts to only one-fifth of the loss by evaporation; the rest of the water comes from the San Jacinto River, the one stream that flows into the lake. This stream traverses 30 miles of farmed valleys between its source in the San Jacinto Mountains and the lake. Its normal flow is completely disposed of by percolation and subsequent pumping for irrigation, and only in times of abnormally large discharge does its water reach and replenish Lake Elsinore. The volume of water in the lake therefore depends on erratic rainfall in heavy storms rather than on high seasonal averages.

The problem facing the community can be solved only by supplying additional water to the lake or by curtailing its recreational use. Since it does not appear to be technically, legally, or economically practicable to divert local water from agricultural use, and since the geographically accessible Colorado River water imported by the Metropolitan Aqueduct is dedicated to urban use in other parts of southern

California, curtailment of recreational use appears to be the only alternative.

The Hill Stations and Summer Resorts of the Orient. J. E. SPENCER and W. L. THOMAS, University of California, Los Angeles.

Abstract: The type of recreational and health resort usually known as the "hill station" is found throughout the Orient. It is always a mountain resort, and is an Occidental institution developed in the nineteenth century in an attempt to find relief from the enervating, moist heat of the lowlands. Ocean beaches have occasionally been used as health resorts, alternative to hill stations.

At the opening of the nineteenth century the role of climate and other natural factors causing ill health was only imperfectly understood. In the first quarter of the century the British and the Dutch, in the course of military penetration of highlands, found that the health of their personnel seemed better there than in the lowlands. These observations led to the establishment of recuperative sanatoriums in the hills to which ailing members of the military services were assigned. By the middle of the century civilians had begun to frequent the hill stations of India and the Netherlands Indies. During the next three decades it became generally understood that the hill station is a useful device for avoiding tropical diseases. Today there are over a hundred well patronized resorts scattered from northwestern India around to central Japan, and in addition many minor and informal highland sites. India has the largest number, the Netherlands Indies the next largest. Siam is the only Oriental country without a hill station.

Within the last two decades the wealthier natives of several Oriental countries have begun to patronize the hill stations themselves. In India, resort facilities have been duplicated for the native population. In China the Chinese have almost completely taken over the resorts, while in Japan Occidentals share cheaper facilities with the Japanese or by paying higher rates obtain exclu-

sively Occidental accommodations. The resort and the summer vacation for the sake of health are now permanent parts of the culture patterns of the native upper classes, and these institutions will remain after the Occidental states have lost political and economic control of the Orient.

Ice-Free Areas ("Oases") in Antarctica.

ROBERT S. DIETZ, U. S. Navy Electronics Laboratory, San Diego, California.

Abstract: Aircraft of the Western Task Group of the U. S. Navy Antarctic Development Project, 1947, discovered two ice-free areas along the Indian Ocean side of Antarctica. These rather extensive "oases" are exceptional because nearly all other known ice-free areas in Antarctica are no more than mountain peaks projecting through the polar ice plateau.

The "oasis" discovered by Commander Burger and his crew is a physiographically youthful land of lakes and other evidences that its drainage is not yet integrated, and is completely surrounded by the ice plateau. The terrain is barren and rugged, with numerous hills rising a few hundred feet to a concordant summit level. It is severely scoured and grooved, and covered with rock rubble; glacial ice, therefore, must have passed over it recently. The lakes occupy scour basins or are impounded by morainic dams.

There is little basis for the widely publicized speculation that this "oasis" is heated by hot springs. Aerial photographs show no evidence of thermal waters or of recent volcanism. Apparently the area became ice-free as a result of the wastage of ice, which in turn became stagnant because of the deflection of glacial ice streams away from the "oasis." The climate in this part of Antarctica is presumably mild enough to permit ice-free "oases" to appear in areas by-passed by the ice moving out from the polar plateau.

Antioqueño Colonization in Northwestern Colombia. JAMES J. PARSONS, University of California, Berkeley.

Abstract: In the sixteenth and seventeenth centuries, Basque and Asturian immigrants were drawn to Antioquia by the discovery of gold along the margins of the old granitic massif that forms the northernmost extension of the Central Cordillera of Colombia. From their fusion with surviving Indians and Negro slave elements arose the so-called *Raza Antioqueña*, a people whose remarkable

cultural individuality has been preserved. Separated from both the Bishopric of Popoyán and the seat of the Audiencia in Bogotá, Antioquia became a self-sufficient mountain community, culturally and economically independent of the rest of New Granada.

As the mines became exhausted, the population increased. Southward expansion of settlement onto the forested slopes of the Central and Western Cordillera began about 1790, and reached explosive force after the revolutionary period (1810-1830). The limited amount of good agricultural land available within the old core area of settlement contributed to the exodus. South of Manizales a further impetus was provided by countless Quimbaya graves, from which large quantities of prehistoric gold trinkets were taken.

Most of the early colonists practised a subsistence agriculture based on corn and hogs. They clung to the *tierras templadas*, at elevations between 3000 and 6,000 feet, and characteristically built their new towns on ridge-tops well above the malaria belt. Introduction of coffee as the major cash crop after 1880 reinforced the pattern of upland settlement. The Department of Caldas, carved in 1907 from the newly occupied Antioqueño lands, has become the leading coffee growing area in Colombia. The fringe of Antioqueño pioneer settlement has pushed farthest southward on the Western Cordillera, where it has reached the vicinity of the Pacific railroad that links Cali with the port of Buenaventura. In Tolima, on the eastern flank of the Central Cordillera, it includes the new municipio of Roncesvalles, 70 miles south of Ibagué. Other fingers of penetration in the north point toward the Chocó, the Sinú, and the valley of the Nus.

The inventiveness and energy of the Antioqueños have in recent years turned increasingly to trade and industry. They have made of Medellín the first industrial city of northern South America. But the drift of *campesinos* from the fields to the factories, especially from the shallow-soiled slopes that surround Medellín, has become the cause of much concern. For these badly worn uplands of old Antioquia, laid bare by colonial mining operations and unfitted for coffee, livestock and dairying offer the most encouraging prospects for the future.

The Importance of the Pacific Basin in Continental Displacement. L. T. HANSEN, Los Angeles, California.

Abstract: The scientists who have speculated concerning the origin of the continents and ocean basins, such as Alfred Wegener, Kreichgauer, F. B. Taylor, Straub, and others, have given too much attention to the contours of the Atlantic and Indian Oceans, and too little to the Pacific. This neglect is one of the main reasons why they did not avoid the fallacies that must have been pointed out by Bowie, Daly, Schuchert, and others. If Wegener had studied the Pacific basin, for example, he could not have insisted that all the land masses are moving westward.

A distinct pattern of Pacific structure is defined by the arcuate islands, the deeps marginal to the continental shelf, the lavas and the deep-focus earthquakes of the Pacific basin. The importance of this pattern is even more pronounced when studied against the patterns of the basins of the Atlantic and Indian Oceans.

The Greenhouse Flower Industry of the San Francisco Bay Area. DONALD I. EIDEMILLER, University of California, Berkeley.

Abstract: The commercial production of greenhouse flowers in the vicinity of San Francisco began in 1895. In that year Edgar W. McLellan, a dairyman of San Mateo, who had found among his San Francisco milk customers an interest in the flowers he was growing as an amateur, began growing them commercially at Burlingame. Additional commercial greenhouses were at first built, like McLellan's, on the San Francisco Peninsula. But after the beginning of the present century two centers were established on the eastern side of San Francisco Bay; one in Richmond and one in East Oakland. Of these two, the latter has become the more important. By 1920 the greenhouses in East Oakland were engulfed by residential housing, and zoning ordinances soon forced most of them to move. The flower growers found new sites farther south, between San Leandro and Hayward.

As a result of the introduction of refrigerated express cars in the early nineteen-twenties, the market of the flower growers was expanded to include, potentially, the whole of the United States. With this stimulus, production was doubled between 1920 and 1929. It is the cool summers of the region about San Francisco Bay that enable the commercial flower growers there to compete successfully with

growers throughout the United States. Better flowers can be grown at the temperatures that obtain in the Bay region in summer than at the higher temperatures that prevail over almost all the rest of the country at the same season. The mild winters of the Bay region provide no comparable advantage. The flowers first produced commercially were roses and carnations. Roses still occupy first place in production, but since 1930 gardenias have become the second most important species, and carnations are now in third place.

The evacuation of all persons of Japanese ancestry from the coast states in 1942 was followed by a sharp deterioration of greenhouses, and the abandonment of some. But even with the smaller area now under glass, the high prices that have prevailed since the war have given a greater dollar value to the flowers produced than they had in earlier years.

The Earthquake: an Agricultural Hazard in Japan. FRANCES M. EARLE, University of Washington, Seattle.

Abstract: Subtropical Japan, with its mountainous interior and its volcanoes, both active and quiescent, is frequently visited by typhoons and even more frequently shaken by earthquakes. Its serene landscape belies the dangerous unrest beneath it. For 1,500 years these islands have had, on the average, one bad earthquake every seven years. Local seismographs register some 500 shocks annually. Losses of arable land through instability of the earth's crust can be readily observed in many rural areas in Honshu and Kyushu.

Many scientific studies of earthquakes and volcanoes have been made; but reports listing losses of human life and property generally stress the cities. Agricultural losses are, however, equally serious. Individual farms are small in size; and since many farmers live near the margin of subsistence any diminution in the productivity of their land or in their harvests is a catastrophe. While individual agricultural losses may appear small, in the aggregate they are large. Losses include not only the original investment in land, but also the labor of a family over long periods of time, the construction and maintenance of terraces, the fertilization and surface fitting of the soil. The destruction of a field cannot be reckoned in precise monetary terms as can the loss of a metropolitan building.

The mature Japanese cultural land-

scape has been achieved by centuries of painstaking, backbreaking work. The major losses from earthquakes result from the destruction or disturbance of this delicately and laboriously balanced landscape. Landslides bury fields that may be irreparable within a generation. Terraces are wrecked, dikes broken, and land tilted so that it is impossible to keep water level in paddies. Fissures are produced in the subsoil that permit water to drain away. The inundation of paddies causes direct loss to growing crops. An offshore earthquake may send a tidal wave to demolish

coastal villages and flood farm land. The interruption of transportation facilities, damage to water mains, cables, sewers, wharves, and docks have indirect repercussions on the farm economy.

The loss of land through centuries has given Japanese farmers a fatalistic philosophy. They accept calmly the damage done by an earthquake, and immediately begin rebuilding terraces and paddies or digging out fields buried under tons of earth. To date it is impossible to say whether the repairs can ever equal the attrition.

Report of the Secretary-Treasurer

THE Secretary-Treasurer assumed his official duties after the meeting at Seattle in September, 1946; this report covers the period from about October 1, 1946 to June 1, 1947.

As of June 1 the Association had 105 full members in good standing, and six student members. About 30 organizations, libraries, and departments of geography have standing orders for the *Yearbook* when publication is resumed. Exchanges are made with several other societies and organizations. It would seem desirable to expand the student membership, and to extend the exchange list and sales of the *Yearbook*. The secretary will welcome receipt of the names of persons who might be interested in becoming members.

The first post-war meeting of the Association was held in Seattle, September 20-21, 1946. Because of the untimely death of the President of the Association, Eliot G. Mears, the Vice-President, John B. Appleton, assumed the duties of presiding officer, and gave the presidential address at the annual dinner.

In accordance with a motion passed at the Seattle meeting, a poll of the membership was taken to determine what date was preferred for the annual meeting of the Association. Ballots were returned by 38 members. Of these, 31 voted for meeting in June with the Pacific Division of the American Association for the Advancement of Science; three for meeting in September, two for meeting during the Christmas vacation, one for a meeting during the last two weeks of August; and one for two meetings per year.

The only expenses of the Association during the year were \$33.00 for a news letter and \$15.70 for postage.

Receipts were as follows: dues, \$207.00; royalty from "The Pacific Northwest," \$88.00; gifts, \$6.00; sales of *Yearbook*, \$24.00. The bank balance of the Association, as of June 13, 1947, was \$486.13.

Because of the large increase in cost of printing, it must be expected that the 1947 *Yearbook* will cost much more than Volume 8, the last published, which cost \$183.38.

OTIS W. FREEMAN, Secretary-Treasurer.

Officers of the Association, 1947-48

President, Harold A. Hoffmeister, University of Colorado, Boulder.

Vice-President, R. M. Shaw, Central Washington College of Education, Ellensburg.

Secretary-Treasurer, Otis W. Freeman, Eastern Washington College of Education, Cheney.

Editor of the Yearbook, John Leighly, University of California, Berkeley.

OFFICERS 1935-48

| Year | President | Vice-President | Secretary-Treasurer |
|---------|--------------------|------------------|--|
| 1935-36 | Otis W. Freeman | George C. Kimber | Willis B. Merriam |
| 1936-37 | Howard H. Martin | Walter Redford | Hallock F. Raup |
| 1937-38 | George M. McBride | John B. Leighly | Hallock F. Raup |
| 1938-39 | John B. Leighly | Frances M. Earle | Peveril Meigs, 3rd |
| 1939-40 | Peveril Meigs, 3rd | Forrest Shreve | Frances M. Earle |
| 1940-41 | Frances M. Earle | J. O. M. Broek | Joseph E. Williams |
| 1941-42 | Forrest Shreve | Elliot G. Mears | Willis H. Miller |
| 1942-45 | Elliot G. Mears | John B. Appleton | J. W. Hoover (resigned) and Hallock F. Raup |
| 1946 | John Appleton | Howard H. Martin | Hallock F. Raup |
| 1946-47 | Phil E. Church | Warren D. Smith | Otis W. Freeman |
| 1947-48 | Harold Hoffmeister | Reginald Shaw | Otis W. Freeman |

THE ASSOCIATION OF PACIFIC COAST GEOGRAPHERS

THE ASSOCIATION of Pacific Coast Geographers was organized on June 27, 1935. The object of the Association, in the words of its Constitution, is "the promotion of scientific research in Geography and the diffusion of the resulting scientific knowledge." Annual meetings are held in June, usually in conjunction with the Pacific Division of the American Association for the Advancement of Science.

Membership is by invitation; and in practice has generally been limited to those having professional training in geography. Student memberships, open only to undergraduate students in geography, carry all privileges except that of voting. Annual dues are two dollars for regular members and one dollar for student members.

The Association publishes annually the **Yearbook of the Association of Pacific Coast Geographers**. The **Yearbook** contains the proceedings of the Association, abstracts of papers presented at its annual meetings, and a few papers selected from those presented to be published in full. The price of the **Yearbook** to non-members and libraries is one dollar per copy.

Correspondence should be addressed to the Secretary-Treasurer, Otis W. Freeman, Eastern Washington College of Education, Cheney, Washington.

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